IRON AND STEEL ENGINEER

J. F. KELLY, Editor

CONTENTS

Volume II August, 1925 Number VIII

Charles S. Proudfoot II

Editorials III

A Discussion of Present Day Wire Rope Problems 311
By James F. Howe.

Foreign Steel Mill Practices 318
By W. H. Burr.

Foreign Steel Mill Practices 319
By F. L. Estep.

Electrical Drives for Rolling Mills 322
By H. C. Uhl.

Observations on Rolling Mill Drives in Continental Europe 327
By O. Needham.

Grounding The Neutral 331
By Edgar D. Sibley.

Orientation of Steel Rod Mills 334
By Guerney H. Cole.

The Super-Synchronous Motor 336
By H. C. Uhl.

Items of Interest 341

(List of Advertisers—Page IV)

Copyright, 1925, by Association of Iron and Steel Electrical Engineers.

Published Monthly by

Association of Iron and Steel Electrical Engineers

706 Empire Building, Pittsburgh, Pa.

Entered as second-class mail matter January 25th, 1924, at Pittsburgh, Pa., under the Act of March 3rd, 1879.

Subscription Price $5.00 per Year. Single Copy 50c.

One of the Leading Spirits that helped to bring about the Electrification of the Steel Industry.

Now General Manager U. S. Ferro-Alloys Corporation, Niagara Plant, Niagara Falls, N. Y.

Charles S. Proudfoot

Starting out as one of the earliest pioneers in Steel Mill Electrification thirty-five years ago, largely responsible for many of the ingenious electrical refinements that exist in the electrical arts today, Mr. Charles S. Proudfoot, has finally reached the goal that comes to those who render service.

On July 16th, he assumed the duties of General Manager at the United States Ferro-Alloys Corporation, located at Niagara Falls, N. Y.

Mr. Proudfoot's achievements are many, his principal one being the Blast Furnace Bell Operated Rig, which later helped him in a large degree to make possible the Automatic Blast Furnace now in operation at the Bethlehem Steel Company at Johnstown, Pa. Mr. Proudfoot was associated with Mr. A. C. Dinkey at Homestead in the early nineties. With Mr. C. A. Menk, 1904 to 1918. With Mr. A. A. Cory at Johnstown in 1918 as electrical engineer of the Bethlehem Steel Company at Johnstown. Within the last year Mr. Proudfoot has supervised the design and installation of a modern power house of 15,000 k.w. capacity, the installation of five 2,000 k.w. motor generator sets and the installation of all the electrical apparatus in connection with 5 modern mills.

Mr. Proudfoot is an active member of the Association of Iron and Steel Electrical Engineers. He is at the present time chairman of the National Papers Committee, and has been responsible for one of the best programs that has ever been prepared for any Annual Convention.

The Association of Iron and Steel Electrical Engineers take this occasion to extend to Mr. Proudfoot their best wishes in his new field of endeavor.

EDITORIALS

WHAT THE IRON AND STEEL ENGINEER MEANS TO THE ELECTRICAL OPERATING DEPARTMENT*

Any publication which strives to fill a legitimate place in the scheme of our normal working lines has a right to exist and to succeed. The Iron and Steel Engineer does serve its readers, and therefore, just as long as we maintain our Monthly publication on that basis, it is entitled to the support of its readers and the respect of its contemporaries.

To me the publication of our Monthly Magazine on its present basis has a three-fold value. It brings each month articles of practical value in the daily work of our Department and Plant, and it publishes, at the same time, a discussion, which gives the viewpoint of various Engineers on the subject of the article, so that we have spread before us a well-executed picture, which we can study and apply to our own problems as they may confront us.

One very vital factor in the value of our Magazine is the character of its advertisements, which keep us constantly in touch with the equipment we use or need, and the Manufacturers of such equipment so that we can quickly and easily locate the proper parties to approach with any new conditions or problems that arise or may be anticipated in our operation.

The foregoing advantages are such as may be enjoyed by any reader of the Iron and Steel Engineer, whether he be a member of the Association of Iron and Steel Electrical Engineers or not. To those of us who are actively interested in the work of our Association the Monthly publication serves as a connecting link, keeping us continually in touch with the activities of sections other than the one to which we belong, and at the same time. bringing us into close contact with the various men who write or discuss papers, and whom w meet otherwise only through the medium of our Annual Conventions, when we can profit by the exchange of personal greetings and experiences of very real value to us all.

Lastly, the regular appearance of the Iron and Steel Engineer each Month serves to remind us of our obligation to help the work of our Association, to contribute to its publications, and to continually strive to advance and perfect the application of electricity to the operations of the Steel Plants wherein we are employed, to the end that more steel may be produced, and greater economies in practice realized.

*Contributed by an Active Steel Mill Engineer.

IRON AND STEEL CONVENTION

Next month the engineers of the Iron and Steel Industry will again be in session. This is their Twentieth Annual Convention. There is much work to do. Competition has become so keen that all industry has awakened to the fact that economical production is absolutely necessary in order to survive. Those industries which have paid little attention to developments in the various arts in the processing of steel are, of course, being hardest pressed. On the other hand those industries which have kept abreast of the times need have no fear. No industry can afford to take the attitude of being contented with the achievements in past, but must ever be on guard and awake to all the developments which are constantly occurring.

A few years ago many of the larger steel companies were satisfied with large tonnages, and this seemed to be sufficient. However, times have changed. The buyers today have become more cautious, more exacting, their specifications more rigid, until not only production, but also quality has become the keynote with the entire steel industry.

A new child has crept to the engineer's door, and every engineer and every executive in the industry must not only welcome him but encourage his growth. This new responsibility is Electric Heat. Today the application of electric heat in the steel industry is what motor application was just about thirty years ago. It required courage and foresight for the engineer to recommend the use of electric drives. What happened? In thirty years over 55 per cent of the steel industry is electrified and if the trend of the times are any indication of the future, in about ten years the steel industry will be completely electrified. Electric Heat has the same possibilities and the same future. There is no question that from this form of heat quality steel will be produced. The Donner Steel Company, in their experiments with the Electrically Heated Soaking Pit, have demonstrated that it is possible to produce a better quality of steel with the use of electric heat than from any other fuel.

The engineers of the steel industry will discuss this problem of Electric Heating at their Annual Convention, being held in Philadelphia, September 14 to 19, 1925.

Many other problems of direct interest to the executives and engineers of the industry will be discussed, namely: SAFETY, CIRCUIT BREAKER PRACTICES, AUXILIARIES AND AUXILIARY DRIVES FOR STEAM GENERATING STATIONS, FROG LEG ARMATURE WINDINGS, HEATING OF INGOTS BY ELECTRICITY, EXTENDING THE HEAT CYCLE IN BOILER OPERATION BY THE USE OF PREHEATED AIR FOR COMBUSTION, ELECTRIC MELTING FURNACES, ELECTRIC HEAT TREATING FURNACES, etc.

The Annual Iron and Steel Exposition is being held in connection with the Convention.

INDEX TO ADVERTISERS

A

Alliance Machine Company 389
Allis Chalmers Mfg. Company 391
American Heat Economy Bureau 361
Appleton Electric Company 386

B

Baker R. & L. Company 387
Benjamin Electric Mfg. Company 352
Bussmann Manufacturing Company 349

C

Cleveland Crane & Engineering Co. 366
Crouse Hinds Company 356
Cutler Hammer Manufacturing Co. 355
Cutter Elec. & Mfg. Co. 360—Cover 3

D

De Laval Steam Turbine Company 364
Delta Star Electric Company 380
Doubleday Hill Electric Company 385–388
Duquesne Light Company 370

E

Economy Fuse & Manufacturing Co. 365
Electric Controller & Manufacturing Co. 346

F

The Fafnir Bearing Company 348
Farrel Foundry & Machine Co. 376
Fawcus Machine Company 385

G

General Electric Company 374–375—Cover 4

H

Harnischfeger Corporation 353
Hyatt Roller Bearing Company 377

I

Iron City Electric Company 380

J

Johns Manville, Inc. 358

K

Keystone Lubricating Company 345

M

Martindale Electric Company 384
Moloney Electric Company 383
Monitor Controller Company 378
Morgan Construction Company 382
Morgan Engineering Company 357
Morganite Brush Company 382

N

National Carbon Company 347
Nichols Lintern Company 392
Norma Hoffman Bearing Corporation 351
R. D. Nuttall Company 369

O

Ohio Electric & Controller Company 362

P

Packard Electric Company 394
Pawling & Harnischfeger Corporation 353
Pittsburgh Transformer Company 389
Pyle National Company 372

R

Reliance Electric & Engineering Co. 393
Roller Smith Company 378
Rowan Controller Company 383
Rumsey Electric Company 388

S

Shepard Electric Crane & Hoist Co. 354
SKF Industries, Inc. 363
Smith & Serrell 379
Square D Company 390
Stackpole Carbon Company 350
Standard Underground Cable Co. 387

T

Thomas Flexible Coupling Company 373
Thompson Electric Company 379
Timken Roller Bearing Company 359
Tool Steel Gear & Pinion Company 384
Trumbull Electric Manufacturing Co. 381

U

United States Graphite Company 386

V

V. V. Fittings Company 371

W

Westinghouse Electric and Manufacturing Company 367-368—Cover 2

Y

York Insulated Wire Works of G. E. Co. 381

A Discussion of Present Day Wire Rope Problems *

By JAMES F. HOWE, M. E.†

IN selecting the different points which I am to discuss this evening, I have endeavored to pick out from a large number of matters that might be commented on, some that appear to me to be more important just at the present time, and I will endeavor to give you the result of my study of these various points.

Safety Factors:

Next in importance to the selection of the proper rope construction to be used in any given place, and directly related to it, is the use of a proper safety factor. In some lines of work, the safety factors used have been more or less standardized, but in wire rope applications, there is in many cases a wide diversity of opinion as to what constitutes a proper safety factor. For that reason, a consideration of safety factors at this time will not be out of place.

There is a tendency in some quarters to use wire ropes with what might be termed very small safety factors. This is probably done in order to save on the sizes of drums and sheaves, and to secure compactness, but in many cases I am confident this has been overdone. In any place where wire rope is used as a means for handling materials or operating machinery, there is always present the question of wear and loss of strength resulting therefrom, coupled with the breakage of the wires after a normal amount of wear for the conditions.

Too small safety factors cause very high bearing pressures of the rope on the grooves of sheaves and drums, and this high bearing pressure causes a more rapid scoring of these grooves, coupled with the flattening of the outside wires in the rope, which sometimes has the appearance of the wires having been peaned or swaged. This effect is increased still further by the wear caused by the flapping or vibrating of the rope, and by bad leads which cause both flange wear and rope wear. There has also to be considered the more rapid scoring of the sheaves and drums, which means a higher expense for upkeep if the machinery is to be kept in good condition at all times, that is to say, if the grooves of sheaves and drums are to be made smooth so that undue wear from the scoring of the drums is to be prevented. A rope manufacturer is directly benefited by a larger consumption of wire rope, due to poor conditions of usage, but it is questionable if such increase of business is entirely beneficial in the long run, because short service brings more or less complaints that the quality of the product has deteriorated, and this is not the reputation that any manufacturer of wire rope wants his product to have, whether true or not. There is a much better feeling all around if a wire rope has given a good account of itself, and it is for this reason that most manufacturers prefer to tell a customer frankly at the outset if his conditions are severe that his results will be poor, and suggest improvements in order that a better record may be made by the rope. The customer will be directly benefited by the longer service.

Length of rope service may vary under different conditions from as short as a week to ten days' minimum, up to ten or fifteen years, maximum. The shortest service is sometimes obtained under severe conditions of mining machine usage, and longest service is sometimes obtained on elevator ropes working under ideal conditions. The time period is, of course, not always a true measure of the performance of a wire rope, and a time comparison of the service of any two ropes is correct only when the work done per day is uniform throughout the duration of the service of the two ropes being compared. To be explicit, safety factors should be ample to allow for reasonable wear and deterioration and still have the rope safe.

The indictment against the use of a low safety factor is clear. Such low safety factor means shortened service, more severe wear, requires closer watching, more careful handling, and there is a greater risk of accident always present.

At this point, a few comments on what safety factor should be used under certain conditions will be appropriate.

Elevator Safety Factors:

On elevators, both passenger and freight, the laws of most of the states provide a minimum safety factor of eight for the main hoist cables, and in some cases a safety factor of 10. These elevator ropes are worked, of course, under conditions where long life is a very important point, together with absolute safety as far as it is possible to get it. The casualty companies who carry the liability insurance, make frequent inspection, and elevator ropes are ordered off when a comparatively few broken wires appear in them. The reason for this is that on elevators, the principal destructive factor in rope service is the repeated bending of the rope around the sheaves and drums. When the wires of a rope have worn down a considerable amount, breakage will take place more easily because the section has been weakened, both in strength and ability to stand bending. This will be true for any condition of rope service. Elevator sheaves and drums are usually of fairly good size, so that in ordering off ropes when a number of wires begin to break, the inspectors feel that they are condemning ropes that have reached the point where the steel has become worn and fatigued to such an extent that it will not safely withstand the bending action for a very long period. As a matter of fact, in any rope some of the wires will start to break ahead of the others, because it is not possible to combine in one rope wires that will all stand exactly the same fatigue stress value, and it is well that such is the case, because the breakage of wires, due to fatigue, being more or less gradual, furnishes an indication to the one inspecting the rope that the time has come for renewal. The goal of the rope manufacturer is to construct rope from materials of such quality that the breakage of wires is postponed as long as possible.

*Presented at Pittsburgh, March, 1925.

†Wire Rope Engr., American Steel & Wire Co., Worcester, Mass.

If all the wires in a rope were to break within a very short period, it would require exceedingly close inspection and supervision in order to catch the danger point quickly. The hardest condition of elevator service at the present time is the modern traction passenger elevator where the speeds are fairly high and the starts and stops frequent and quick. All of these factors contribute to reduction in the life of wire rope, and even under these conditions, ropes will frequently travel from 20,000 to 50,000 miles before they have to be taken off.

For elevator work, the minimum ratio of sheave diameter to rope diameter on ropes composed of six strands, nineteen wires, is about 48, and for ropes of eight strands, nineteen wires, the minimum ratio is about 40. On governor ropes of smaller size, these values are somewhat smaller, a value of thirty times the diameter of the rope being frequently used for ropes of eight strands, nineteen wires, because such ropes are easily renewed, and the cost of the ropes and renewal is not very large.

I have referred to elevators, because this is one of the cases where the safety factor has been standardized for a longer time than probably any other class of service.

Safety Factors on Cranes

On inside overhead traveling cranes, particularly on hot metal cranes in steel mills, the safety factor of eight for a new rope has been taken as a standard

Special Flexible Hoisting Rope 6 strands, 37 wires each, one hemp core.

by some of the large steel producing companies. The hoisting of ladles of hot metal is, of course, a dangerous operation, and every safeguard possible should be thrown around the handling of such hot metal. Since wire rope is the means by which this handling is done, and since any accident or damage to the wire rope is almost certain to cause an accident which will be fatal to human life, some comments on ways and means for safeguarding such operations is of vital importance. It is usually the case that the amount of head room inside the buildings where steel furnaces are located is limited, and it taxes the ingenuity of the designer of a traveling crane to secure all of the essentials for such an equipment.

Another important point to be considered in addition to the safety factor on a wire rope (which, as already stated, should not be less than eight for handling hot metal), is the diameter of the sheaves and drums to be used on crane service.

One of the largest steel producing companies has adopted a value of thirty times the diameter of the rope for the minimum diameter, of sheaves and drums on cranes for hoisting purposes, this value to apply only to ropes composed of six strands, thirty-seven wires, a construction known to the trade as special flexible hoisting rope. This rule has been frequently disregarded in the case of equalizer sheaves, which in the past have been made smaller than any other sheaves, with the result that trouble at equalizer sheaves has occurred frequently, due to the severity of the bend, and the small movement back and forth over the equalizer sheaves, which causes broken wires. Equalizer sheaves ought to be as large as the other sheaves, or else an equalizer bar should be used and the rope dead ended to the two ends of the equalizer bar.

The reason for the size of sheave and drum specified has already been commented on with respect to durability, bearing pressure, and of course, bending stress, and while the ropes are being operated in some plants where sheave diameters are less than the figure given, and where safety factors are less than eight, still the results obtained by such severe use of the rope are shown by the increased amount of rope used, and of course the greater risk of accident which is always present under such conditions.

Safety Factors on Blast Furnace Skip Hoist:

The conditions of service on blast furnace skip hoists are more or less uniform, and the rope is in operation almost constantly, carrying the loaded skip to the top of the blast furnace and dumping it. In general characteristics, this service does not differ appreciably from that of a mine of shallow depth operated at a steep slope. The skip wheels run on the track, and the rope is attached to the bail of the skip.

As mentioned under mine hoists, it is customary on inclines to use a safety factor a little higher than is used in the case of a direct vertical lift. This is partially due to the friction and the possibility of more wear on a rope used on an incline than where rope is used vertically. It is also true that the operation of a

Long Lay Haulage Rope 6 strands, 7 wires each, one hemp core.

blast furnace skip hoist is very similar to an elevator which is required to handle a large amount of material per day. If we were to classify this service in the same manner as elevators, we would probably take safety factors as high as eight. A safety factor, however, of six or more, should usually give good results and, of course, the skip is not used for conveying men back and forth, and the additional safety factor used on regular elevator construction need not, therefore, apply. Increasing the safety factor beyond six would not be necessary, except that perhaps a somewhat better rope service might be obtained, provided, of course, the sheaves and drums are proportioned so not to increase the stress in the rope due to bending. In general, the diameter of sheaves and drums for this class of service should be proportioned very liberally, because the failure of the rope for this class of service would be due largely to the bending which it gets. Hoisting ropes, six strands, 19 wires, one inch diameter, ought to have sheaves and drums at least five feet in diameter, and proportionately larger for the larger sizes. This will keep down the bearing pressure as well as the bending stresses to a reasonable amount, and good results should be obtained. The path of the rope should also be so designed that the bends will all be in one direction, if it is physically possible to do it, because a reversal of the bend on this as well as any other operation, will reduce the life of the rope very materially.

Mine Hoists and Inclines

While steel plants are not directly interested in mining rope conditions, still the iron ore and coal used

comes from the mining operations, and some of the conditions under which ropes work in mines are applicable to service conditions in and around steel plants.

A vertical mine shaft is in effect a high speed elevator for raising the ore or coal to the surface. In some mines, the same rope is used both for hoisting men and materials. It is usually the practice when men are hoisted to reduce the speed and take other safety precautions. The number of men raised or lowered is arranged so the load being handled will give a good safety factor. There is a different practice used in the case of very deep mines from that used in mines that are comparatively shallow. A larger safety factor is used on the shallow mines than on the deep mines, which at first thought, appears to be wrong, but on second consideration, it will be seen that with a long rope there is enough elasticity to absorb shocks due to starting and stopping, accelerations and decelerations. I think it is borne out by facts that safety factors as high as 8 or 10 on shallow mines do not give any higher safety factors than 5 or 6 on deeper mines. Applying

Extra Flexible Hoisting Rope, 8 strands, 19 wires each, one hemp core.

this same principle to other operations, it would be easy to see the reason for higher safety factors on short lengths of rope.

In a vertical mine shaft, most of the wear comes by passing over the sheave and drum, but if the mine shaft is inclined so rollers must be employed, additional wear and pounding occurs from the vibration of the rope in its travels up and down the slope. To allow for the increased wear and to help out conditions so the life of ropes on slopes will not be shorter than ropes on shafts, it is customary on mine slopes to use a higher safety factor than on vertical shafts. This cannot be entirely accomplished, but it can be aided by the use of a larger safety factor on an incline than would be used on a vertical lift. In other words, if a shaft of reasonable depth has a safety factor of five, the slope should have a safety factor of not less than six.

Car Dumpers

Car dumpers are usually employed for the handling of coal and other materials in loading boats at docks. These are in effect on large elevator platforms onto which the car is pushed, clamped, and then the platform is raised or tilted until the coal runs out down a chute onto a boat or into a pocket for further transfer. The speed of operation of the ropes on car dumpers is slow, and consequently the stresses due to starting and stopping are not very heavy. There is, however, considerable wear on the ropes due to the number of sheaves over which they must run, and the variation in the leads which is incidental to the operation of such machines. Equalizers are employed on some of the machines. It sometimes happens that these equalizers are not designed to fully take up the difference in tension between the different parts of ropes employed, and it is not uncommon at times to see certain ropes running tighter than others. This, of course, gives an unequal distribution of the load on ropes in question, and will cause the ropes carrying the heavier load to wear out more quickly. If this condition is found to exist, steps should be taken to correct it by providing suitable equalization, because it is no doubt true that there is more trouble due to lack of proper equalization on equipment of this kind than from any other cause. The same thing is true on regular passenger elevators, but I rather think that more attention is paid to this matter on regular elevators than is done on car dumpers. Even if the ropes are originally put on and adjusted, it may easily happen that a difference in diameter of grooves on multiple sheaves will cause a tightening up of one set of ropes, and the slackening of the other set due to the difference in diameters. If suitable equalization is provided, all the ropes will take their portion of the load, and little or no trouble should be experienced.

For the sake of compactness, the sheave diameters on car dumpers cannot always be made as liberal as manufacturers would like to have them. In those cases, it is sometimes necessary to provide a rope of a little more flexibility than the standard 6x19 hoisting rope. Such a rope is constructed of six strands, twenty-nine

Standard Hoisting Rope 6 strands, 19 wires each, one hemp core.

wires, which has fourteen wires outside on each strand in place of twelve wires as is the case of the 6x19 rope. There are a few car dumpers where it has been found nececsary to use six strands, thirty-seven wires, in order to get sufficient flexibility. The safety factors on equipment of this kind, should be six or better, because the work is heavy and continuous.

Ore Handling Machinery

This sub-division covers a large range of equipment on which the direct means for handling the ore is usually some form of clamshell bucket. It is here in many cases that all of the rules for sizes of sheaves and drums have been violated, because it is impossible to get them as large as would usually be recommended.

In the past, it has been found that ropes of six strands, nineteen wires, in many cases were not flexible enough, or the conditions were such that the regular style of hoisting rope would not give satisfactory service. Part of the trouble in some cases has been due to the fact that designers of clamshells have taken care of all the mechanical features before they started to consider the rope problem, with the result that the rope was supposed to bend back and forth and reverse itself without any regard to longevity. A great many buckets have been used in which the conditions of rope service are exceedingly poor. A few buckets have been designed in which the path of travel of the rope through the clamshell is always in the same direction. This is, of course, a decided improvement, particularly in the case of a closing rope, which is the one that usually stands most of the grief and has to be renewed oftenest. The holding rope, as a rule, being dead ended to the top of the bucket, or, at least, passing around only one sheave on the top of the bucket, almost always lasts quite a little longer than the closing rope, and it is the practice in many cases to order the closing rope enough longer so that pieces can be cut off from the bucket end when this end has worn down so as to make it unsafe.

The contention of many rope manufacturers is that not enough attention has been given by designers of clamshell buckets to the conditions governing rope service, and improvements in buckets along these lines are possible without radical changes in the general design.

The short service of ropes on clamshell buckets is not attributable to the quality of the rope, because the same ropes in other places give very satisfactory service. An attempt has been made by the company with whom I am connected, to improve the service on such equipment by designing ropes of intermediate flexibility between the six strands, nineteen wires, and six strands, thirty-seven wires. These are known as 6x29 and 6x33 ropes, respectively. Considerable improvement has been effected by the proper use of these ropes. Co-operation of the designers and users of such equipment with the manufacturers is certain to result in considerably improved service on ropes for clamshell bucket work.

Certain features in the design should be provided for, if possible:

1. All bends to be in the same direction.
2. Sheaves as large as possible.
3. Provision of rollers or guides to prevent rope becoming jammed by bad leads, incidental to the operation.
4. Provide additional drum space to allow for longer closing ropes so the worn ends may be cut off more frequently and service increased.

The safety factor to be used on a clamshell bucket, due to its speed of operation, liability to shocks, and general characteristics of service, should be fairly high. The value of 8 to 10 in the case of fast moving buckets, and 6 to 8 in the case of slow moving buckets would seem to be imperative.

Locomotive and Wrecking Cranes

This general class of equipment is used very largely around steel plants for handling of materials, and is usually arranged to permit the use of clamshell bucket operation. All that has been said with regard to ore handling equipment and clamshell buckets applies to locomotive cranes.

In order to secure compactness, drums and sheaves on this class of equipment are very small. In fact, they cannot be reduced any further without the rope service being very materially lessened. In some cases, it would seem that a more liberal design of the drums and sheaves would be possible and result in considerably increased rope service.

The only other place where sheaves run as small is on derricks used in quarries and building operations where speeds are very slow. It is not possible in most cases to use very high safety factors on this class of equipment, because, in order to secure compactness, the rope diameter is kept down. If a safety factor of five exists on such equipment for all classes of loading, and in the case of clamshell bucket operation this is 6 or 8, it is about all that can be expected.

Number of Rope Parts

Still another point, which should be given very careful consideration, is the number of parts of rope to be used in a hoisting fall. It is a comparatively easy matter to increase the number of parts of rope in a hoisting fall until it has sufficient strength to make a given hoist, but when this is done, the more parts that are used, the faster the hoisting speed of the drum will be as well as the ropes around the sheave blocks, in order to get a given hoisting speed of the block as a whole. There is, of course, less pull on the hoisting drum under these conditions, but there is a decided disadvantage, and that is that too many parts of the small size rope brings in a more or less dangerous element because the smaller rope is more easily damaged. If any accident happens to the hoisting mechanism to cause a surge of load, such as the failure of the hoisting hook to properly seat itself on a ladle trunnion, it almost always happens that wire rope will break at a point between the drum and the first sheave of the block. The reason for this is, that when a sudden shock or load comes on a multiple sheave block, there is insufficient time for the stress in the rope to distribute itself uniformly around through the various parts. The result is the heaviest load comes on the single part between the drum and sheave block where it is the least able to carry it and decreases through the other rope parts, resulting in overloading the rope and causing breakage. A safety factor of eight may be reduced to 1½ to 2 in a case of this kind, and if the safety factor before the surge is less than eight, it is almost certain that the rope will break. It would be better practically with certain sizes of rope to limit the number of parts in any hoisting block, so that if a heavier load is to be lifted, a larger rope will be required to perform the task. (I am not in favor of increasing unduly the number of sheaves in a hoisting fall.) I believe that the following figures underneath the zigzag diagonal line should be considered a maximum for the best practice.

Overhead Traveling Cranes

Maximum number of Rope Parts recommended for various loads with 6x37 Monitor Rope, using two sets of blocks with one-half of the tabular number of parts in each.

Rope Dia.	5 Tons	10 Tons	15 Tons	20 Tons	25 Tons	30 Tons	40 Tons	50 Tons	75 Tons	100 Tons	125 Tons
⅜ in.	8	16	24	32	38	46	60	76			
½ in.	5	9	14	18	23	26	33	42	62	82	102
⅝ in.	3	5	8	10	13	15	20	30	45	60	75
¾ in.	2	4	6	7	9	11	14	18	26	35	44
⅞ in.	2	3	5	6	7	9	11	14	21	28	35
1 in.	2	3	4	5	6	7	9	11	15	22	27
1⅛ in.	1	2	3	4	5	6	7	9	13	18	22
1¼ in.	1	2	3	4	4	5	6	7	11	14	18

For a single set of blocks, one-half of the figures below the zigzag line should be used.

While this recommendation imposes limits on the crane builder, I am convinced that it is a step in the proper direction, and one that should be given most serious consideration in any new installation or in any improvement of existing cranes, particularly those used for handling hot metals. It is not always desirable to go the extreme that these figures give, as it is better to err on the side of a smaller number of rope parts of larger rope in a hoisting block.

Crane Operation

In the case of some hot metal cranes in steel foundries, the ladles are handled on a single hook block, and the pouring is done at a point some distance away from the steel furnace. When the ladle is transported by the crane from a point where the furnace is tapped to the place where the castings are poured, there is a certain swaying, and if this swaying is excessive and the ladle is being hoisted at the same time to clear ob-

structions from the floor, there will probably be severe wear against the flanges or grooves of the drums. This will be shown by wear along one side of a rope in practically a straight line. Of course, wear on one side of a rope is not always due to this condition, but it is more pronounced in such places and can only be guarded against by moving the ladle more deliberately from one point to another; also, to start and stop with less acceleration. The same comments would apply whatever material was handled. Of course, if the load being handled is raised up nearer to the crane trolley, there will be less swaying and faster speed in handling will be possible. It will, however, require time to raise the load before moving it from point to point and lower it again.

Equalizers

These should be used where more than one rope is used or where a rope fall is split up into two parts or sets of falls. In the past not enough attention has been paid to this subject, with the result that trouble has resulted from the use of poor equalizers with sheaves smaller than others used in the same block. As already stated, broken wires are sure to appear at the bend on small equalizer sheaves and make a dangerous place in a rope which will require its removal before it has worn out in any other place. If the two ropes being equalized are not too long, they may be dead ended to opposite sides of an equalizer bar in place of having an equalizer sheave and the rope in one piece.

Inspection and Testing of Rope

There is a wide difference of opinion as to how safe a rope is, and how long it should be left on. On elevators, reference has already been made to the general practice of discarding ropes. This may be considered as very conservative. It means, however, in some cases ropes are left on until they are pretty well broken up. Not so very long ago, one of the large iron mining companies that had a large number of slopes, started the practice of testing the ropes which they took off to determine the strength of these ropes. The results of these tests were somewhat surprising. It was found that in some cases, ropes which were taken off had only 60% of their original strength. These particular ropes, of course, contained a great many broken wires in the test length, and it was this large number of broken wires that accounted for the large reduction in strength from the original test figure. In making these tests, the only way to secure reliable results is to socket the ends of the test specimen with zinc. It may not be out of place to say that when a wire rope is first put on, its strength after a short service, increases by a small percentage, due to the settling down of the strands into the core and a slight stretching of the rope. Immediately thereafter, however, the strength begins to fall off gradually as the rope wears or as the wires begin to break. The wear alone is not of itself as serious as wear and breakage. In fact, a rope may be pretty well worn, and yet when the test is made on it, it will be surprising how little reduction there is in the ultimate strength. This is due, of course, to the fact that the wires in the strands only wear at the point where they come in contact with the sheaves and drums, and elsewhere the section of the wires is normal.

In passing judgment as to whether a rope should be taken off, care should be taken to see that all the conditions are given due consideration. Broken wires in a rope should be analyzed for general location and distribution. Single wires broken in a strand, if separated by a distance of say three ft. from each other, will reduce the strength of 6 strands, 19 wires, rope only by 1/114th. Several broken wires in one spot, however, will reduce the rope strength materially, because the rope construction is out of balance. At that point, when such a rope is tested, it invariably happens that the strand containing the broken wires in one spot breaks first, because it is unable to carry its share of the load. This is why a worn spot or a jammed spot in a rope is dangerous, whether the rest of the rope is good or not, and is the reason why a very careful inspection should be made at regular intervals to find out the condition of the rope. In the case of ropes on hot metal cranes, it is not too often for the crane operator to look his ropes over every day, and have a special man to look them over at least once a week. If there are any indications of abnormal wear in any spots, the condition of the rope should be reviewed by the master mechanic in charge of operations, and he should determine if the rope should be replaced.

Wire Rope Efficiency

There is among some engineers a false idea as to what constitutes the strength of a wire rope. Some have the idea that the strength of a wire rope is equal to the sum of the strength of the wires taken individually, and I have known cases where there has been added to this value the strength of the hemp center. It is apparent, if only a little study is given to the proposition, that the strength of a hemp core has no bearing on the strength of a wire rope, because the elongation of hemp rope is many times that of a wire rope, and it is further evident for the same reason that the strength of a rope is not equal to the sum of the strength of the wires, but is a value somewhat less than this. Rope manufacturers refer to the efficiency of a rope as being the ratio of the actual strength of the rope, and the sum of the strength of the wires composing it. It might be assumed that a wire rope, whose efficiency was the highest was the best rope for general purposes, but this is not so. It is true from a standpoint of strength alone, but strength is not the only factor to be considered in a wire rope. It is one of a group of factors. Where strength alone is to be considered, such as in the case of guy rope or bridge cable, a rope with a high efficiency is desirable, and this is accomplished by making such ropes up with fairly long lays in order to secure as high a strength as possible.

The reason that the efficiency of strands and ropes is less than unity is readily explained by considering the characteristics of the construction. Where the wires are twisted into a strand, they make an angle with the axis of the strand which we will call O. The shorter the lay of a strand or rope, the greater will be the angle O, and conversely the longer the lay, the smaller will be the angle O. The value of the strength of a strand of rope is directly dependent upon the value of the cosine of the angle O, at which the wires of the strand or the strand in the rope are twisted. Considering a strand, the line of action of its strength is parallel to its axis or passes through the center wire of the strand, while the strength of the wire composing the strand is exerted along the axis of the wire which is twisted at the angle O to the axis of the center wire. It is only necessary, therefore, to resolve the force

acting along each wire to one acting along the axis of the strand. If F is the sum of the forces acting along each wire, then the total force acting along the axis of the strand is F cos O. In arriving at this value in a simple case of a strand of 7 wires, we may take the strength of the center wire as unity, and the strength of the six surrounding wires as 6 x cos O.

It will be interesting to know that the prevalent idea that a bundle of straight wires would have an efficiency of 100% if tested as a group is not entirely correct. This has been the assumption of engineers in bridge construction in the past. On the most recent suspension bridge now being constructed, tests were made by at least two rope manufacturers to determine the value of a group of wires that would be used in the construction of such a bridge. The Company with whom I am connected made a very careful test of a group of eighty lengths of wire, each 7'0" long, all cut from the same bundle, very carefully straightened in a rotary straightener, grouped together, and the ends socketed with zinc. Each of the wires had a diameter of .192, and the sum of the strength of wires was 484,040 lbs. The tests of these wires as a group showed a strength of 460,000 lbs. Dividing this latter figure by the former gave an efficiency of 95%.

One bridge engineer with whom I talked prior to the time of the test, stated he believed that there would be a difference of as much as 10% in the distribution of the load on a series of wires erected in a suspension bridge. At all events, the tests on the group of 80 wires indicated that the best it was possible to get on a very careful factory test was about 95%.

With the lays ordinarily employed in hoisting cables, the average value of cosine O in a 19 wire strand will be approximately .95, and approximately the same cosine figure for the lay of the strands in a rope. Multiplying these two figures gives us a possible efficiency of .90 for the strength of a wire rope. This value, however, is not equaled, except in rare cases, because of some other factors which enter into a wire rope test as well as into the rope manufacture.

It has been shown that there is a possible reduction in strength of 5% in a bundle of straight wires. If this 5% is deducted from the 90% obtained by considering the angle of lays alone, there will be a value of about 85½%.

It is found that the medium sizes of wire rope will usually give a value as high as this when tested as a whole in a testing machine. Not all of this last deduction of 4½% is caused by the unequal distribution of load. Part of it is caused by the nicking action which takes place under very high stress where the strands touch each other. This is more pronounced on the smaller sizes of rope than on the larger ropes, and it is not uncommon to find ropes that will show an efficiency within 2 or 3% of the possible theoretical maximum of 90%. This shows that the manufacture of ropes has reached a point where the twisting and laying operations have been refined to a point where they are more reliable in the production of strength than can be produced by the use of a bundle of straight wires.

There is another point which also has a bearing upon the strength of rope, and that is the forming of wires in the strand and the strands in a rope. The bending of high strength wires causes a slight reduction in tensile strength, probably at least 2 or 3%, varying somewhat with the size of rope being made, and the machinery being used for its manufacture.

Monitor or Improved Plow Steel Rope

The past ten or fifteen years have seen a marked tendency of rope users to employ the strongest and highest grade of rope. There are a number of good reasons for this with which most engineers are familiar. The principal ones, of course, are that the use of a high grade rope, such as Monitor, permits a larger safety factor on existing equipment without necessitating other changes. It also permits the use of smaller rope in some cases, particularly if crucible steel ropes were previously used. It is not such a great number of years ago that crucible steel rope, as it was known to the trade, was the rope principally stocked by rope manufacturers and dealers. At the present time, plow steel is very largely stocked, and the crucible steel is only used where conditions are not very severe. It is, of course, obvious that if the same diameter rope is loaded heavier, the duty required of it is more severe than would be the case if a larger rope of material not as strong were used. This fact should be understood in connection with the analysis of troubles, which sometimes, develop from the use of high grade rope. Many of these are not the fault of the rope, but rather the stepping over of the boundary line of what might be considered the limit of stress that should be placed upon a rope of this grade.

To take a concrete example, a 1¼" standard crucible steel hoisting rope would have the same strength as 1⅛" standard plow steel hoisting rope or as 1", standard Monitor hoisting rope. With the reduction in diameter of 1¼ to 1" there will be a 20% increase in bearing pressure, and while the Monitor wire is harder and will withstand more wear in the same diameter than the crucible steel due to surface abrasion, there are cases where, in place of reducing the size of rope, the best results are obtained by increasing the grade in order to secure increased wearing qualities and consequent fewer renewals that go with it.

Flexibility for Rope Service

For many years, ropes consisting of 6 strands, 19 wires, were considered standard for general hoisting work. There were then developed two other more flexible constructions: one of 6 strands, 37 wires, and one of 8 strands, 19 wires. In conditions of service, where ropes overwound on drums, both the 8 strands, 19 wires, and 6 strands, 37 wires, as made were somewhat unsatisfactory because they crushed and flattened quite easily from this overwinding—the 8x19 even more so than the 6x37. However, there have been developed in recent years some intermediate constructions which give more flexibility than the 6x19, and still are rugged enough to withstand overwinding on drums. Two of these intermediate constructions are 6 strands, 29 wires, and 6 strands, 33 wires, respectively. In order to get a slight increase in flexibility, it is not necessary now to jump from 6 strands, 19 wires, to 6 strands, 37 wires, construction. This is particularly true on such pieces of apparatus as locomotive cranes and wrecking cranes where the general conditions are very severe, owing to the small diameter of sheaves and drums over which the rope must work. This is particularly true in the case of locomotive cranes equipped with clamshells, because there is hardly any class of service where the rope is subjected to as much abuse as it is on a clamshell. This is something that cannot be entirely taken care of by the design of such a machine, because the way the machine has to be operated, the rope will not

lead fairly at all times, and there will be more or less dragging and spotted wear.

Considerable success has attended the use of 6x29 and 6x33 ropes on clamshells on locomotive cranes. This is a comparatively new development in the rope manufacturing art.

While mentioning locomotive and wrecking cranes, it may not be out of place to refer to a feature that exists in some of these machines, and that is that the boom ropes are frequently not made with as large a safety factor as the main hoisting ropes. In some cases, the manufacturers depend on machine up-ending if it is overloaded, but this cannot always be relied upon, for the reason that it is possible to tie such a machine down to the track or weight it to make a heavier lift. In such cases it is possible to break the boom rope without the hoisting rope suffering damage.

A case which came up a few years ago is illustrative of this. A locomotive crane was equipped with eight parts of rope in the boom hoist. Because of this condition, there was an accident, caused by breaking of boom rope from overload, in which several men were killed by the dropping of the boom. This had to be increased to 12 parts in order to get a safety factor on the boom fall to equal that of the main hoisting rope fall. At that time, it had been recommended that men should not work under the booms of locomotive cranes, but that matter was gone into still further, and the boom rope increased so that whether the men get under the boom or not, the boom will not fall in the future.

In another case, a locomotive crane was found intended for use as a single part rope hoist. It was actually being operated with a two part rope and the boom rope under this condition was only half as strong as the hoisting rope. In that case, the size of the hoisting rope was cut down to about one-half the strength, and ¾" rope put on in place of 1" diameter to prevent overloading.

Recently, the question was put up to the speaker as to how large a rope should be used to transport machines weighing three tons between buildings about 100 ft. apart, and upon stating that 1¼" 6x19 plow steel rope with 7 ft. sag in the center would have to be used, I was informed that the last time the job was done they used ⅞" or 1" rope. It was painfully evident that the safety factor in the previous case was too small, but this is an error that is frequently made by riggers in suspending ropes horizontally, and it is something that should be very carefully checked before using ropes on spans for moving objects from one point to another.

Wire Centers

In order to increase the strength of ropes, it has been found necessary in some cases to add a wire center. This center is a smaller rope of the same strength as the larger rope surrounding it. The advantages obtained by the use of wire center are the increase in strength, and the decrease in the crushing on drums where there is severe overwinding, but of course, such ropes are not quite as elastic as hemp center ropes, and their use is confined largely to such places as dredges, steamshovels, drag excavators, and the like. In some cases, on hot metal cranes, it has been the practice to use ropes with soft iron center. These do not increase the strength of the rope, but they do prevent any drying out or burning out of the core due to the heat. I am convinced, however, that it would be better if the regular style of wire core were used in most cases, because a soft iron center has a deadening effect on a rope, and results in cutting down the elasticity.

The best type of wire center is one composed of 6 strands, 7 wires, or 6 strands, 19 wires, placed inside of the outer six strands. The material in the wire center should be approximately of the same grade as the material in the outside wires. Such a wire center not only supports the rope, but increases its strength, and does not have the effect of cutting down or bending the rope, although it will prevent undue stretch where loads are very heavy. Excessive stretch, of course, will stiffen a rope and set up stresses that are likely to cause kinks if slack is allowed to come in the rope after the stretch has become excessive. Where ropes overwind on drums, it has been found that wire center being more rigid prevents the flattening of a rope, thus keeping it in better shape, and longer service is usually obtained. These general remarks will give a fair understanding of what the wire center will do.

Careful attention is paid by the manufacturer to the wire center which is put into a rope, because this is something that should not be used hit or miss, but only to accomplish a definite result.

Measurement of Rope Service

Many rope users are keeping records of ropes used, so the cost of rope per unit of production may be readily determined. There are different ways by which these records may be kept. One of the common ways of keeping a record of the rope service is to record the date on which the rope is installed and the date on which it is taken off. The difference between the two dates in years, months, and days, is a time measure of the service obtained. Time measure is easily obtained, but it is not always a satisfactory unit. Other factors enter into consideration, so that the time factor should be used only in cases where the daily amount of material handled by the rope is fairly uniform. In the case of mine hoisting rope, a record is kept not only of the days of services, but usually of the net tons of material hoisted. In comparing two ropes under that class of service, the tonnage hoisted is usually found to be a better measure of the performance of the rope than the length of time is. In places where a tonnage value cannot be obtained, but the number of trips or lifts can be recorded practically automatically by means of a counter, the measure of rope service will be the number of trips made. In the case of car dumpers, for instance, the number of cars dumped would be a fairly good measure, because the average weight of the cars handled would not vary greatly. The method used for measuring rope service on elevators is length of time or distance traveled, because for such classes of service the amount of work performed per day is fairly uniform. Therefore, in comparing the performance of any two ropes, consideration should be given to the conditions under which the ropes work, and due allowance made for conditions that have worked against the best performance of the rope. Not the least of such factors is the general condition of the equipment, such as sheaves, drums, etc., as well as the skill of the operator who is handling it. In fact, the personal element has a large bearing on the service obtained.

Improvements in Rope Manufacture

There has been in the last decade a closer study on the part of rope manufacturers of the conditions under which ropes operate, and more thorough know-

ledge of the operation of such ropes has been obtained. This has led to gradual improvement in rope constructions, as experimental ropes have been tried out under various conditions of usage. Ropes are now given a thorough lubrication, and the wires are selected with great care to secure uniformity of physical properties and a high standard of hemp core is used.

Testing of short pieces of new ropes to destruction is now frequently done in order to check up the entire rope manufacturing process. In fact, for some classes of service, it is advisable to test every length of rope produced, not that there is a big variation, but the confidence that the customer has in such rope is increased by the knowledge that a full size section of the finished rope has been proof tested.

In conclusion, let me say that I am confident that an intelligent study of conditions surrounding any rope usage will bring out the facts in favor of or against the rope, and result in a better understanding both on the part of the manufacturer and the user of a product, which is the vital connecting link to successful engineering operations today.

(Discussion on This Article Appears on Page 338)

*Foreign Steel Mill Practice**

By W. H. BURR†

BEFORE starting on this paper a brief word of explanation may not be out of order. When this topic was assigned to me at our meeting in August, last year, I planned that I would have this subject, "Foreign Steel Mill Practice," divided so that one engineer would handle each of the following subjects: Blast Furnaces, Open Hearths, Reversing Mills, Continuous Mills and Power Generation.

To find the engineers to handle these subjects was something entirely different, and after considerable time, it was given up. The logical thing to do, then, was to have those engineers who had consented to help with this paper write on the subject which they felt best qualified to handle. This was done, and although there are some points which have been covered by each engineer, I felt that it would detract from the individual paper if omitted, so they will be given as prepared.

Business conditions in the Local Steel industry have changed since this paper was suggested and I know that every man who presents a paper has felt recently that he did not have time to devote to this work, and I am sure most of the work was done at home. I wish at this time to express my appreciation to those who present these papers, for I realize that it has meant a personal sacrifice on the part of each one.

To handle a paper on "Foreign Steel Mill Practice" as it should be handled, one should, at least, have visited foreign Steel Mills. Not having had an opportunity to do so, it is necessary for me to depend on the other members of the committee, or obtain my information from articles published on this subject.

I took occasion to write to a representative of a manufacturer of Foreign Mills, now in America, on this subject and was advised that he was sent to this country to learn more of Steel Mill Practice in America, as it was considered superior to that in foreign countries. This brought up the question, "Why is this the case?" In order to understand the real reason for this I believe it would be well to consider first of all the conditions which are primarily responsible for the development of the steel industry as it exists in the world today. Modern machinery, however good, is not alone capable of producing steel at a minimum cost. Certain natural conditions must exist to permit of the production of steel economically.

First: An ample supply of coal, a large portion of which is suitable for making coke, must be available.

Second: Ore suitable for making steel must be obtainable at a low cost.

Other necessary conditions, such as a supply of suitable flux and good labor conditions, have less bearing on the situation than the first two mentioned. In addition to the above, machinery of suitable design for the production of the particular grade of material manufactured is necessary to meeting present day competition.

It is estimated that 51.9% of the world's coal is located in the United States, 16.7% is in Canada, 13.5% in China, 2.3% in Siberia, leaving 15% divided in smaller percentages between the other nations of the world. The richest coal beds known today are on the Western Slope of the Allegheny Mountains. The Twelfth International Geological Congress estimated the reserve coal supply in the world was 7,397,553,000,000 Metric tons.

With 51.9% of all the world's coal supply you can understand one of the reasons why United States leads in the production of steel in the world today.

Mr. O. R. Kuhn, of the Midvale Steel & Ordinance Company, in 1922, estimated that the iron ore reserve in the world, which could be used commercially, was 32,555,500,000 Metric tons. Twenty-three percent of this amount is located in Brazil, 20% in the United States, 16.3% in France, 11.2% in New Foundland and 9.7% in Cuba. The remaining 20% is divided in smaller percentages among the other nations of the world.

The ore supply in Brazil is so located that it is not accessible because of the lack of coal and transportation facilities. At the present time the United States leads in the production of iron ore, the richest iron mines in the world being located near Lake Superior. In as much as more coal than ore is used in the production of steel the logical place for steel plants is near the coal supply, other conditions being equal.

United States today pays from 1½ to 4 times the rate paid for labor in England, and Continental Europe pays only approximately ½ what England pays. So that one of the most serious problems of the steel industry in United States today is that of common labor. Mechanical labor saving devices cannot be carried to the extreme. Often the interest on the investment

*Presented at Philadelphia, March 7, 1925.

†Elec. Engr, Lukens Steel Company, Coatesville, Pa.

makes the cost of operating the labor saving device prohibitive.

Transportation charges in England are much higher than in the United States or in most of the countries in Continental Europe. This is due to the fact that right of way was more expensive, cost of construction greater and labor cost also higher. One author states that not so long ago British Steel Workers produced 46 tons of steel per man, per annum, Germany 60 tons, while in United States 76 tons per man, per annum, was produced. Trade Union regulations in England also make it difficult to compete with foreign trade.

The World War left England in a much better condition than the countries of Continental Europe. This can be realized when you consider that at the time the Battle of the Marne was fought, 90% of the ore production of France, 86% of the pig iron production, 78% of the coal supply, 76% of the production of steel was in the hands of the enemy.

When the German General Staff saw they could not retain the territory invaded they employed experts who prepared a report giving data concerning plants in France that competed with them and proceeded to carry away or destroy the equipment to prevent further use.

Ninety-one Blast Furnaces, 38 Bessemer Converters, 39 Open Hearth Plants and Rolling Mill equipment, used in connection witth the steel producing plants, were destroyed or carried away. Nor did it end with this, for the collieries were damaged to the extent of 2,500 million francs, and it will be at least 10 years before the output of coal will be back to the point reached before the war. As a result, France will be seriously handicapped in the production of steel for some time.

As a result of the war, Germany's available supply of coal for the present is only 30% of what it was before the war. She will have to import most of the ore she uses from France, probably in exchange for coke, or from Sweden on which a heavy duty will no doubt be charged. The return of Lorraine will be a serious economical loss to Germany, in addition to the loss of 9,000,000 population and all her colonies. To this is added the fact that her financial position is very unsatisfactory.

From the above, you can readily see that the supremacy of the United States in the steel industry, is in no danger of being taken away. The fact that this nation excels all other nations in production of steel is one of the principal reasons why we should study carefully the manufacturing of steel as carried on in other countries, and by so doing should be better qualified to make recommendations on future installations and maintain this supremacy.

With the above facts in mind you may be better prepared to understand why present conditions exist in Foreign Steel Mills today. This condition will be described in the papers which are to follow by the members of the committee.

---

*Foreign Steel Mill Practice**

By F. L. ESTEP†

Observations of Rolling Mill Practice In Scotland, England and Wales

DURING five different visits which the writer has made to England, he has had occasion on each of the trips to visit one or more of the various steel companies in regard to work which was being carried on and for the sake of information in regard to practice in general.

We would first like to make a few remarks in regard to the steel itself.

According to record, about 93% of ingots made in Great Britain are by the open hearth process, and about 7% by the Bessemer. Many of their ores are not suitable for Bessemerizing. The greater part of the pig iron, from which the steel is made, comes from various local ores, supplemented in some cases with imported ores and in other cases made into pig iron without any mixing. In many cases local ores are calcined before going in the blast furnace and thereby brought up in total metallic content. Some of these ores, as mined, will run only from 22% to 24% metallic iron, and when calcined will run from 26% to probably 30%. Most of the ores which were imported into England for mixing with local ores originally came from Spain, but during recent years the Spanish ores are beginning to fall off in quantity and quality. So England is bringing in ore from other sources and making further efforts to utilize their own ores without mixing.

Coming to the question of open hearth ingots, the practice in the open hearth department is very similar to ours, in that steel is made in stationary furnaces with a mixture of scrap and cold pig iron and in several plants made from scrap mixed with hot metal direct from the blast furnaces.

The quality of steel as compared with common practice in the United States is much better. In other words, the manufacture of steel in England up to date has not been a high tonnage proposition such as ours, but has been quality first, and tonnage second.

Generally speaking, their open hearth practice is very good in regard to heats made per unit of time, fuel consumption, etc.

It might be well to mention here that their furnaces are not large in size, there being comparatively few that are much over 50 tons in capacity, and therefore their heats are small, and one thing which is noticeable to a close observer is that after the steel has been tapped into the ladle an unusually long time is taken for teeming. In other words, the steel is poured fairly cold and they use a very small nozzle. As a matter of fact, a very great percentage of the steel is poured through 7/8" nozzle, and an inch and an eighth is a very large size.

Ingots are poured into molds, the same fashion as is done here, except that practically all ingots are cast in pits and not on cars.

On account of this, it is common practice to have the soaking pit building adjacent to the open hearth on

*Presented at Philadelphia, March 7, 1925.

†Consulting Engr., 40 West 40th Street, New York, N.Y.

the pit side, in some cases going at right angles to the line of furnaces and in other cases parallel to the line of furnaces.

The ingot sizes vary for the purpose intended. Many large size rectangular ingots are poured for plate, and to the best of the writer's knowledge, most ingots for rails and large structural shapes range in size from 20x20 to, say 20x24," and weigh from 6,500 to 9,000 pounds. Ingots for sheet bar and tin bar as well as many ingots for small merchant material are poured in much smaller size, a common size being about 14" square and weighing approximately 3,200 pounds.

Practically all ingots are heated in soaking pits much the same as ours, but their handling facilities for getting the ingots into and out of the pits are not comparable to ours for speed. Many of the devices would look to an American engineer like a make-shift proposition, but they answer their purpose. Their soaking pit buildings are not heavy like ours, and neither do they have as much ingot heating capacity per blooming mill as is customary in this country.

Blooming Mills

Taking up now the subject of blooming mills, the writer has seen five of the large and modern blooming mills, all of which except one were engine driven. These blooming mills are very rugged in construction, and we would like to mention here that whereas in our country the size of a blooming mill is specified by the pinion diameter, the size as spoken of in England is the roll diameter.

Although the blooming mills, such as the writer has seen, are capable of exceedingly high tonnage, so far as the mill proper and its prime mover are concerned, there are several features in connection with the installations which the writer has seen which prohibit high tonnage.

In the first place, as mentioned above, they do not have sufficient heating capacity to give full production. In the second place, many of the devices for handling at the mill itself, that is, manipulator, side guards, various types of turning device and screwdown on the mill itself, are all too slow.

Furthermore, provided these two features were corrected, the writer has yet to see a blooming mill which is provided with sufficient room and handling facilities to take care of a high tonnage.

Large blooming mills, such as referred to above, throughout a year of operation, will only average between 30 and 35 tons an hour, whereas there are many blooming mills in this country that will average from 90 to 110 tons an hour for every hour of operation throughout a year.

There is, of course, one very good and sufficient reason for this lack of high capacity. In England there are many blooming mills, and therefore, the tonnage required per blooming mill is very low, and although they must have a mill of sufficient size and ruggedness and equipped with sufficient power to pound an ingot down to a bloom or slab, they do not need the other features which have been mentioned as having a bearing upon the blooming mill capacity.

Also some of the blooming mills are handicapped at once by driving one, and sometimes two, pair of rolls through the blooming mill stand from the same drive.

The writer has in mind one new and very fine installation of a 40" (roll diameter) blooming mill, which has two outside stands and which mill is equipped for rolling rails.

The ingot is bloomed down on the blooming mill itself to about an 8" x 8", is run back from the blooming mill far enough to have the front end cropped and is then transferred on the back side to stand number 2 and after 4 passes in Stand No. 2 again transferred on the back side to stand number 3 and finished in a total of 6 passes beyond the blooming mill into a rail direct, the whole ingot being rolled into one rail. During the case observed by the writer they were rolling an 82½-pound rail from an ingot that would weigh probably 7,000 pounds.

The obvious thing to do to speed up the capacity of this mill, provided it were warranted, would be to put a separate drive on the outside stands and leave the bloomer as a single unit. However, the mill is built up against the property line on the outside and this is impossible.

In many cases structural shapes were rolled in just the same way, namely on a heavy mill driven through the blooming mill. In other cases, and in one late installation in particular, the finishing part of the mill is separated from the bloomer, but they roll shapes direct down to 12" I-Beams and channels.

The last installation, just referred to above, is a very good one, and from the American standpoint of high tonnage, so far as the mills themselves are concerned, lacks only an intermediate rougher.

In this installation the blooming mill is separate. The finishing mill consists of three stands, number 1 and number 2, driven by one engine, and number 3 the finishing stand, driven by a separate engine, the mill being located beyond the blooming mill with stand number 1 in line with the bloomer and a shear between.

Again, in this particular case, there are insufficient handling facilities beyond the mill to take care of a sustained high tonnage and heating facilities in front of the bloomer to put it up to maximum tonnage.

Plate Mills

The writer has seen several plate mills in operation both in Scotland and Wales, some of them very old mills, and the writer recalls one in particular upon which plate was rolled for skelp, which mill, from the standpoint of operation, meaning tonnage produced and range of width, length and gauge rolled, was remarkable.

This mill consisted of a 2-high, 2-stand engine driven reversing unit. Reheated slabs were cornered in the usual way on stand number 1 until width was secured, the slab rolled out into a plate probably 5/16 to ⅜ of an inch thick and then transferred on the back side with a mechanical device to stand number 2. The roughing stand had a hand screw-down operated by a boy, with both screws geared together in the usual way.

Stand number 2, on the other hand, was operated with two separate screws, the inside screw next to the rougher being operated by the screw boy who had just been running the screw-down on the rougher, while the outside screw was operated by another lad and both screws were set by signal and gesture from the roller.

Crude as this might seem to us, we wish to repeat that it was remarkable how easily and quickly they handled the plate on the finishing stand, and the length and thinness produced on this stand were extreme. By

the separate individual handling of the two screws, the rollers seemed to have the plate under absolute control.

One other plate mill which was of interest was a very large single stand plate mill in Wales, which was motor driven, and which again was 2-high reversing. One of the most interesting things in connection with this mill, other than the massiveness of construction of the mill proper and front and back tables, was a device located under the front table for the turning of the slab.

This consisted of a lifting "Fulcrum" point which could be brought up between rollers at any desired point under the slab and the slab turned quickly and correctly by the starting up of the table rollers either in a forward or backward direction.

This particular mill was equipped with sufficient sized hot beds for properly cooling, and shears for shearing at a high rate of tonnage, but beyond the shear there was no means for taking care of a sustained tonnage such as this mill would be capable of.

Bar Mills

The writer has seen several bar mills, mostly in Wales, where ingots about 14" square and weighing 3,000 to 3,200 pounds were rolled into sheet and tin bar.

Most of these mills consist of two stands and again are 2-high reversing. The first stand is used for breaking the ingot down into an 8" or 10" wide slab and has a device for turning the ingot 90° when occasion required for certain passes.

In most cases, after the bar is transferred to stand number 2, it is given 3 passes in the finishing stand.

Compared to our sheet bars and especially our tin bars, bars rolled in Wales on such mills as mentioned above, are approximately twice as thick because their thin sheets and tin plate packs are made from one bar.

In many cases this sheet or tin bar is finished with beveled edges so that a bar, say 8" wide and ¾" thick in the center, is beveled down on both edges to perhaps only ⅜ of an inch thick. This is for the purpose of making the bars enter readily in the roughing stands of the sheet and tin mills where the roll diameters are somewhat smaller than ours, particularly in the tin mills.

Merchant Mills

The writer has seen only a few of the older types of merchant mills in operation and has not had the pleasure of seeing any of the more modern ones, and therefore, cannot make any interesting comments on this type of mill.

Sheet Mills

The writer has been in one sheet mill where the majority of the production is converted into galvanized sheets of 26 and 28 gauge.

This particular mill was engine driven, and the hot mills were 28" in diameter, each mill consisting of 2 stands, a rougher and a finisher, with balanced top roll on the rougher and pinion driven, while the finisher was of the "Jump" type.

Tin Mills

The writer has confined a great deal of his attention to the hot and cold mills of the tinplate plants in Wales, and in connection with this type of mill there is a very marked difference between their installations and ours.

In the first place the common roll diameter in the hot mills is 22" with comparatively few 24", which are "big mills." There are even some mills which have 19" diameter rolls, but these are very few and are being replaced. Many of these would probably have been replaced sooner by 22" or 24" diameter rolls, except for the fact that the particular drive was not of sufficient power for the larger diameters.

All tin mills in Wales consist of 2 stands, a rougher and a finisher and, as mentioned above, a pack is made from one bar.

Their process of roughing in particular is very interesting. Two bars are brought from the furnace at one and the same time and are laid on the foreplate, or in some cases, on a pair of legs only in front of the rougher in the usual way by hand.

This roughing stand has individual screws with no crossbar and no ordinary type of lever such as we have. A sort of a wheel is put on each screw with turned up pegs, say about four to the circumference and the rougher does his own rolling and is his own screw boy. He roughs, with one hand, bars usually with beveled edges and approximately ¾" to 1" thick in the center which, in many cases, will weigh 40 to 60 pounds.

He starts with a level top roll, that is, with screw set even, and after giving both of the two bars one pass, he will, with his short tongs in his right hand, reach over and pull the right screw with his left hand, then with his right hand give the two bars one additional pass each; as soon as the second bar is stuck he will swap his tongs to his left hand and pull the left screw with his right hand and give the bars another pass. Thus the operation is continued until he has given them as a rule 5 passes and any of you would be surprised to see how exactly alike in length, width and shape this pair of bars leave the roughing stand. After this initial roughing operation the bars are returned to the furnace for reheating.

The next operation consists of taking one of these two bars either on the roughing stand or on the finishing stand, dependent upon weight of bar, condition of rolls, etc., and draw it as a single bar out to a length which will permit of doubling.

Beyond this second operation there are three more operations, making five total with 5 heats. The last three operations are always on the finishing stand. After the third operation, the pack is doubled into fours, and after the fourth operation, is doubled into eights and finished in the fifth operation in the usual way.

The finishing stand does not have any crossbar and each screw is worked individually.

It will be seen that the roughing stand is idle a very large percentage of the time and therefore the production per mill, although up to the limit of capacity of human endurance, is much lower than in the United States for several reasons, primarily among which is the fact that the bars have to be rolled 5 times total.

The writer would like to mention that it is common practice to run the finishing stand of each hot mill with very hot necks, much hotter than is customary in this country, and the rollers have been accustomed by years of training and service to adjust themselves to this condition and nearly every finishing stand is also run with very tight screws.

It might be interesting to you to learn that the overcoming of this tight screw feature and the breaking

up of the idea that the finishing stand necks must be terribly hot, was one of the hardest things to overcome with the Welsh rollers taken to India to work on the hot mills there. The Indian mills were double mills with mechanical doublers and both roughing and finishing stands were equipped with water jets for the top roll necks and a steam jet for control of temperature and contour.

A hot mill crew for the Welsh mill tin mills, up till the latter part of 1921, consisted of 4 men only, namely, a roller, doubler, heater and catcher. The work was extremely hard on these men, and due to this and the fact that very few, if any, comforts are provided for the men at and about the hot rolls, many of the Welsh rollers have worn themselves out by the time they are 45 or 50 years old. That this latter is a fact, was borne out by the results of medical examinations given the rollers who were considering the Indian proposition and the greater majority of them over 42 years of age were physically unfit to take to India.

In regard to cold mills in Wales, here again the diameters are smaller than ours. Where our cold roll diameter is 24", you will find that most of the cold rolling of tin plate is done in Wales on rolls 18" or 19" in diameter and there are some few mills left, about 17" in diameter.

In some of the latter mills the cold rolls are laid out for tandem working, some 2 pass and some 3 pass, and where 3 passes are required on a 2 tandem pass installation, the sheets are brought around after pass number 2 and given a third pass on the second or third outside stands of train number 2.

The first thing that would strike anybody is the labor used in handling at the cold rolls. If there be, anywhere in Wales, a conveyor beyond these various stands of rolls, the writer has yet to find out where it is.

The plates are carried from the back of, we will say, pass number 1 in train number 1, usually by girls, to the front side of train number 2 for pass number 2, and ditto for pass number 3, if there be 3 trains in tandem. In the United States we have had conveyors between these rolls for years and the sheet is entered by hand once only, namely, in pass number 1.

In regard to roll turning, both hot and cold mills are almost universally turned in the housings, the drives being equipped with a slowing down device to give a slow speed, and this turning is done on Saturday afternoons and Sundays.

In closing, we wish to say that in our opinion the most striking thing from an American viewpoint, in connection with any and all of the mills in Great Britain, is the lack of production per mill unit per year, and per unit of investment.

In other words we mean this: If all of the tonnage produced on all of the blooming mills in England, Scotland and Wales were put together, you would find that a comparatively few modern blooming mills with full and sufficient equipment for heating, quick handling at the mills and getting rid of the tonnage beyond the mills, would take care of the entire production.

The same applies to all of the different types of mills.

The writer wishes to predict here that it is only a question of a very few years until there will be forced in Great Britain, a combination of various interests with just this purpose in view, namely, modernize their equipment and combine their interests so that each unit can produce its full tonnage throughout a year.

---

*Electrical Drives For Rolling Mills**

By H. C. UHL†

THE methods used abroad for rolling steel are naturally very interesting to us in this country because we like to know how the other people are solving the same problems that we have, and from this information see where we may improve our own practice. After all, we are all striving to better our own practice with the idea of rolling more steel with the least possible consumption of energy and with the minimum investment in machinery consistent with reliability and safety, and at the same time have the resulting product the very best that it is possible to obtain.

From the valuable contributions that are made from time to time to your Association, and which are published in your proceedings, and from the interesting discussions, we know quite well what the best American practice is. Since we have such a vast market for finished steel products and such keen competition, our methods are quite different from the methods used abroad. We have developed mass production, continuous mills, etc., where the initial investment is quite large, but where the economies resulting more than compensate for the methods we use. Thus, our mills are highly specialized, and on one mill we roll only one or only a few types of product because we can readily dispose of the entire output.

The conditions abroad are entirely different and, especially since the War, it has been difficult to finance the more expensive types of construction and equipment for mills. Owing to a more limited market, one mill is usually called upon to roll a large variety of products and not concentrate upon one or a few types of shapes, except in special cases. This means that rolls are frequently changed, which procedure is extremely objectionable in this country, except where absolutely necessary. The question of economy is much more stressed in Europe than in America and methods for economizing in the cost of mills and in the use of power are much in evidence. The question of labor cost also enters in, and many operations are not accomplished automatically by machinery abroad that we find quite essential to accomplish by machinery in this country.

In Europe the mass production scheme is not in evidence, although the tendency seems to be in that di-

*Presented at Philadelphia, March 7, 1925.

†Industrial Engr., General Electric Company, Schenectady, N. Y.

rection where conditions permit, and a few mills have been built and more contemplated with this in mind.

In this paper we intend to discuss quite briefly the electrical equipment for various rolling mills, and will endeavor to point out where the practice abroad differs from our practice in this country.

One quite noticeable thing in European practice is the rather limited use of squirrel cage induction motors in small sizes and the more extensive use of wound rotor induction motors. This is not only noticeable in steel mills but in all mills. The wound rotor induction motors are also frequently provided with schemes for lifting the brushes from the collectors and short circuiting the collectors when the motor is up to speed to increase the operating efficiency by eliminating the brush friction and brush and cable losses. The more extensive use of the squirrel cage type of induction motor, because of its simplicity and reliability, would be justified abroad, particularly in the smaller sizes.

There also seems to be a more extensive use of commutator alternating-current motors abroad than in this country and we will have to admit that many of the types that we are using more generally now were originally developed abroad.

Especially on the medium and larger sizes of induction motors of the wound rotor type, liquid rheostats are frequently used for starting duty, while in this country, we usually use grid resistances, even when flywheel effect is desired, and use the liquid rheostat for comparatively few applications, except as slip regulators. There are exceptions to this, as, for example, in England some manufacturers frequently use grid resistances for starting.

Gearing is now used extensively abroad, but rope drive was used quite extensively for a time, where speed reduction was necessary or desirable.

Schemes for controlling motors involving quite complicated arrangements are frequently used, especially if their use will show a considerable saving in power. In this country we are inclined to feel that the extra complication would not justify their use.

Electrical Equipment for Non-Reversing Mills

Because of its ruggedness and simplicity and because the power supply is usually alternating-current, the wound rotor induction motor is largely used abroad as well as in this country. Flywheels are extensively used in conjunction with liquid slip regulators. The generally conceded best practice abroad is to mount the flywheels separately in their own bearings.

The motors are usually built with extremely heavy construction, corresponding to our mill type construction, but are seldom built with stator movement, which we use so generally in this country.

Some interesting arrangements are used which are worthy of comment. The motors are sometimes provided with shaft extension on each end with the same size bearings on each end, even though only one end drives, and since the motors are symmetrical on each end, if desired, the motor may be turned around on its base in case of necessity, due to injury to the shaft. One prominent manufacturer on the continent arranges the stators of induction motors with removable feet and on some sizes with removable pins holding the stators, so that the stator may be rotated to facilitate repairs. The stators are always split to facilitate removal of the rotor and repairs to the stator, since no stator movement along the base is provided. Frequently on slow speed motors of large diamater the stator is stiffened by the use of reinforcing arms across the ends.

Adjustable-speed drives are very frequently used, which we would deem quite desirable, because such a wide variety of products are rolled on the same mill. If adjustable speed is not used on such mills as merchant mills, etc., it is necessary to provide for the most efficient speed for the heavier sections and sacrifice tonnage on the lighter sections. Owing to the lack of capital, this is often done, although many adjustable-speed drives are used. Both alternating-current and direct-current drives are used, although at the present time, since many efficient schemes are available, alternating-current is usually used. Direct-current was formerly more generally used for ordinary drives.

Resistance regulation of wound rotor motors is rarely used, which conforms to our practice in this country. Some multispeed motors are used, but they are not extensively used because of the limited number of steps and the inherently poor efficiency and power factor.

Alternating-current commutator motors have been used for drawing rolling mills directly, but their use has been restricted to small sizes and they have not been found practicable for large sizes. Some series type brush-shifting, alternating-current motors have been used on small rolling mills with quite constant loads, but in a very limited way because of the series characteristics. Some shunt alternating-commutator motors have been used of the Winter-Eichberg type and other types, but then only in small sizes. In this country we have also successfully applied several Schrage alternating-current, brush-shifting shunt motors in comparatively small sizes for rolling steel (500 and 600 h.p., 25 cycles), but for large sizes at higher frequencies they cannot at the present time be built.

For alternating-current service and large size motors the really successful adjustable speed drives use the wound rotor induction motor with auxiliary apparatus in the secondary transforming the secondary energy in one way or another. By these methods the power factor may also be improved. This also has the advantage that the capacity of the auxiliary apparatus need be made only to accommodate a portion of the complete energy, depending upon the amount of regulation desired and upon the methods used, whether regulating from synchronism down or both above and below synchronous speed.

Various schemes are used abroad for obtaining adjustable speed with wound rotor induction motors.

The Kraemer system is widely used for regulating the speed of the induction motor below synchronous speed. In Europe, as in this country, it has not been found feasible by this method to obtain double range operation, i. e., operation both above and below synchronous speed, because no satisfactory way has been found to permit the induction motor to go through synchronism with load.

This system, as is well known, uses a rotary converter converted to the slip rings of the induction motor, which converts the slip energy into direct-current and either returns this energy to a direct- current motor on the same shaft and thereby mechanically to the drive, or returns this energy to the line through the medium of a motor-generator set. The scheme usually used in Europe, as in this country, is to use the direct connected direct-current motor, returning the energy mechanically to the drive, although some of the other types of drives

have been built. This usual scheme is a constant horsepower scheme.

The drives are frequently made suitable for driving from either end and sometimes the direct-current motor is overhung outside the pedestal bearing of the main drive. Six phase rotary converters are usually used in Europe as in this country, because in this way the rotary converter is less expensive. When flywheels are used, the direct-current motor on the shaft of the main motor is coupounded. Due to the fact that the compounding effect varies with the speed, i. e., due to the different flux required by different shunt field strengths, an indirect method of compounding is often used. This result is obtained by the use of a small supplementary booster connected in series and differentially with the main field winding of the auxiliary direct-current motor. This supplementary booster with two field windings is usually placed on the exciter set used for the excitation of the rotary and direct-current motor fields forming a three-unit exciter set.

The Kraemer system is well adapted for high slip frequency equipments, i. e., large speed range, but due to the fact that the rotary converter synchronous torque becomes small as the main motor approaches synchronism, and at this point sudden load fluctuations tend to pull it out of step, it is not feasible to operate close to synchronous speed. Between synchronism and the point where stable operation is obtained, we have a gap in the speed range.

Various schemes are used abroad utilizing commutator motors in conjunction with wound rotor induction motors for obtaining adjustable speed. The most important of these schemes is known as the Scherbius system. This is particularly important because of the possibility of obtaining regulation both above and below the synchronous speed of the induction motor. We will have to claim the credit for making the first practical scheme of this sort in this country, although in Europe the same principle is now used, but the method of obtaining it is somewhat different from the scheme used in this country.

The single range Scherbius scheme usually consists of a wound rotor induction motor with a separate motor-generator set, consisting of a commutator motor and a squirrel cage or wound rotor induction motor, and the equipment necessary to adjust the field of the commutator motor for injecting an adjustable voltage at proper frequency into the secondary circuit of the induction motor. For the single range equipment the capacity of each unit of the motor-generator set depends upon the amount of regulation desired. On this scheme, as on the Kraemer system, it is not possible to operate close to synchronous speed with the regulating equipment, and the equipment operates regulating only below synchronous speed.

For the double range Scherbius scheme, i. e., operating both below and above synchronous speed, the same apparatus in general is used with the addition of an auxiliary exciter either direct connected to the main induction motor or geared to it for producing the excitation for operation at and near synchronous speed, and which is further utilized for power factor correction. Advantages claimed for the double range equipments by the Brown Boveri Company are: Better efficiency throughout the speed range, the advantage of being able to operate the mill a considerable portion of the time at synchronous speed which is in the middle of the speed range, the ease of adding this equipment to increase the speed of existing mills, the perfectly stable operation obtained, the advantage of obtaining power factor correction at all loads including light loads, and the uniformly good commutation and operation under the severe conditions obtaining in rolling mills.

The commutator motor used in this scheme is usually connected to an induction motor forming a motor--generator set and feeding power into the line for single range operation and both feeding in and drawing power from the line for double range operation. This scheme is inherently constant torque. Commutator motors direct connected to the main induction motor are also used, forming a constant horsepower arrangement. The scheme using a separate set means that the size of the commutator motor may be reduced, as it is possible then to choose the most economical speed for the set and use a smaller number of different sizes of sets.

The Scherbius scheme is very well adapted to equipments having a slip frequency not in excess of 15 cycles. On the double range modification smaller machines may be used for a given total regulation than on the Kraemer system or the single range Scherbius system with absolute stability at and near synchronous speed.

On the double range system geared ohmic drop exciters are used frequently, although in this country ohmic drop exciters direct connected to the main motors and with the same number of poles as the main motor are used. With the double range scheme power factor correction is easily incorporated.

When flywheels are used, the commutator motor is compounded to obtain flywheel effect, but the compounding is not adjustable, due to the complication. In this country none of the double range Scherbius equipments in operation are arranged to utilize flywheel effect.

The essential difference in the double range Scherbius schemes used abroad and in this country is in the control of the ohmic drop exciter circuit. In this country a resistance arrangement using a constant potential on the exciter is used. Abroad a transformer with taps is used to supply a variable voltage to the exciter. In Europe both the transformer and the exciter scheme are used for obtaining the normal excitation of the commutator motor for single and double range operation, while in this country we now use the transformer scheme exclusively at the present time because of the greater simplicity.

Other schemes utilizing commutator alternating-current motors are also used, a different type of commutator motor being used. These are usually made with the commutator motor direct connected to the main induction motor forming a constant horsepower arrangement. The adjustable speed feature is obtained single range by altering the excitation of the commutator motor by varying the excitation volts by means of a transformer connected in the secondary circuit. Power factor correction is obtained by interconnecting the phases of the exciting transformer. The commutator motor may be wound shunt or compound. Comparatively few equipments of this type have been built. Another modification of this scheme is to gear or belt drive the commutator machine to keep its size down.

When the amount of regulation desired is greater than a total of 50 per cent, it has been found more economical to use direct-current motors for driving the rolls and converting the power from alternating-current to direct-current.

Rotary converters are often used for this purpose; also arranged for power factor improvement. Small rotaries are usually started from the a-c. side, like an induction motor, but larger sizes are usually provided with a three-phase starting motor of about 10 per cent of the capacity of the rotary. Motor-generator sets are also used for transformation from a-c. to d-c.

A much greater use of mercury arc rectifiers is made in Europe than in this country, especially in large power units. The action is based on the valve action of the mercury arc in a vacuum. When an arc is struck between a mercury cathode and an iron anode in a vacuum, it has the property of allowing current to flow only from the anode to the cathode, and of imposing a practically infinite resistance to currents flowing in the opposite direction. The direct-current obtained from the rectifier bears a fixed relation to the applied three-phase voltage, i. e., the line to line a-c., three phase voltage must be 1.6 times the desired direct current voltage plus about 28 volts. For 250 volts d-c., the a-c. volts must be 428 v. and for 120 d-c., the a-c. voltage must be 220 v. The power available from the rectifier depends upon the current and cannot be designated as a fixed number of kilowatts. For example, a 500-ampere rectifier can deliver 250 kw. at 500 volts and only 55 kw. at 110 volts d-c. The internal voltage drop of the mercury arc is independent of the applied voltage and almost independent of the current or the load. Thus the efficiency is about constant at all loads. The efficiency is dependent on the d-c. voltage since the internal drop is almost a constant value of volts and does not vary with the d-c. voltage. Up to 250 amperes glass containers are used. For high currents either several glass rectifiers up to five are used in parallel or rectifiers with iron containers are used.

The advantages claimed by the Brown Boveri Company and the A.E.G. are as follows: High efficiency, which is nearly constant at all loads, simple to start and little attention required; also, do not have to synchronize, small wear, minimum upkeep and almost complete freedom from noise, small floor space required, insensibility to short circuits and peak overloads. The highest possible d-c. voltage should be used in order to obtain the highest efficiency and least expense.

Ward-Leonard equipments are sometimes used for non-reversing rolling mills. Motors and generators have separately excited field windings. To save on the control, the exciter fields are controlled. This system combined with flywheels, may be used to advantage to keep the intermittent peak loads from the three-phase system, where it is not feasible to use flywheels on the rolling mill motor. The motor-generator sets are usually called Ilgner sets, and by this method the flywheels may be made smaller than if they were on the mill motor, and the rolling mill speed may be regulated independently of the flywheel energy stored up.

Booster sets are also sometimes used with d-c. rolling mill motors when greater than three to one speed range is required, and when the d-c. supply is at constant potential. The boosters alter the voltage on the armature of the driving motor.

For large section mills direct-current motors with Ilgner sets are frequently used.

In England there has been a long controversy as to the advantages of the two-high mill and the three-high mill for plate mills, which still persists. Recently a large equipment was installed, using what is in effect a reversing motor for a three-high plate mill driven by a 2,500-horsepower motor supplied by an Ilgner motor-generator set. The following advantages are claimed for the arrangement: The speed of the mill motor is under the operator's control, so that heavier passes can be made at slow speed and the subsequent lighter passes at high speed (obtaining the inherent advantages of adjustable speed), the flywheel is independent of the mill and removed from its shocks, lighter gearing may be used between motor and mill, a smaller flywheel may be used, because on the Ilgner drive a 20 per cent drop in speed is permissible, which is greater than the permissible variation on the direct drive; time may be saved on this mill by making the first passes reversing, which reduces the number of lifting table operations and then operate the motor non-reversing and use the lifting tables as the piece becomes longer. Thus, the advantages of both types of drive are obtained.

Continuous mills are being introduced slowly in England and on the continent, because of the greater cost and because of the feeling that the output of such a mill is greater than can readily be sold.

Experience abroad, both in England and on the continent, has shown that electrical drive is more economical than steam drive.

Electrical Equipment for Reversing Mills

The first reversing mill was started up in Germany in 1905. There are now more than 100 electric reversing mills in Germany alone. Reversing mills are usually used for work which involves the rolling of a considerable quantity of metal at one time as ingots, heavy shapes, thick plates, etc., where it is desirable to move the material back and forth in the same plane without having to lift it. Practically all the driving motors are direct connected and separately ventilated and the large sizes have double armatures and all have split field frames and compensating windings to balance the effect of armature reaction. The motor-generator sets usually are arranged with 20 per cent speed reduction for flywheel effect. The flywheel motor-generator sets or Ilgner sets have several generators which gives the advantage of smaller units and higher speeds and therefore smaller flywheels. The induction motors are in one unit per equipment. The generators have distributed compensating windings to balance the effect of the armature reaction. Water-cooled bearings are often used on the motor-generator sets.

Where several large motor-generator sets with flywheels (Ilgner sets) are used to supply several mills, the flywheel sets are usually coupled together, as this permits a reduction in the rotating masses and saves friction losses. Often magnetic couplings are used to readily connect and disconnect the various units when running. Switching is provided so as to be able to switch the generators around to one or several equipments when not running. This has never been done in this country.

For the large Ilgner motor-generator sets, barring motors are usually provided to break the sets from rest, causing an oil film to be formed, and to overcome the static friction, after which the barring motors are disconnected and the sets brought up to speed in the usual way. The barring motors bring the sets up to only a very low speed, in the neighborhood of about 3 r.p.m. or more. By the use of barring motors, several units may be readily turned over to connect the couplings together when ordinary couplings are used. Barring motors are not used in this country.

Brakes are often used on the flywheels, even with a water-cooling arrangement, to quickly bring the large motor-generators to rest. The motor-generator sets are also slowed down electrically by reversing the induction motor primary leads or by the use of direct current.

Sometimes a Kraemer equipment is used in conjunction with the large motor driving the Ilgner set to save the power which would otherwise be lost in the resistance when the flywheel effect is utilized. In Germany, especially, phase advancers are frequently supplied with the induction motors to improve the power factor and thereby permit a greater output from a given size of motor.

A very interesting installation has recently been made by the A. E. G. in Germany in one of the rolling mills on the Rhine. The equipment supplies one blooming mill and one billet mill, rolling large sections. This equipment uses Ilgner flywheel sets and direct-current motors on the mills. The Ilgner set consists of three units coupled together, using three induction motors each with a phase advancer, seven generators and two flywheels. The complete set is approximately 200 feet long. Switching is provided for connecting various generators to the different motors when not running. The induction motors have 95 per cent leading power factor at full load. Barring motors are furnished for starting from rest after which liquid rheostats are used. Flexible couplings are provided between the different units, although the couplings of each individual unit are of the rigid type. The flexible couplings are arranged on each side of the flywheels.

In Europe the generators of the Ilgner motor-generator set are often provided with differential compound windings to damp the current peaks, but in this country it is the opinion that the addition of such windings tends to make the equipments more sluggish in operation.

The European practice in the control of the reversing equipments is quite different from the practice followed in this country. In this country the field of the reversing mill motor and the fields of the generators are controlled direct. The excitation is supplied by means of a motor-generator exciter set. In Europe the usual practice of many of the large manufacturing companies is not to control the fields of the reversing motor and the generators direct, but to control the excitation of the exciters. This, of course, requires the use of separate exciters for the driving motor and the generators. The explanation usually given for this practice is that the control is simplified, because it is necessary to handle only the small current of the exciter fields instead of the relatively large current of the main motor and generator fields. This scheme presents a number of operating advantages but so far has not been used in this country.

In this country some manufacturers use one two-unit motor-generator set consisting of a driving motor and an exciter for the excitation of both the motor and generator fields. Another manufacturer uses a three-unit exciter set consisting of a driving motor, a constant potential exciter for the excitation of the motor and generator fields and another variable potential exciter having a series field winding connected in the main armature line. The armature of this exciter is connected to a separate field winding on the mill motor, giving in effect a series winding without the necessity of reversing a series field on the mill motor when the motor is reversed.

Various schemes are used abroad for supplying the excitation of the reversing motor and the generators and for speeding up the excitation. One manufacturer uses two three-unit exciter sets, plus one additional auxiliary machine with a flywheel for this purpose. One exciter set consists of a driiivng motor, an exciter for the excitation of the reversing motor field and an exciter for the excitation of the exciter fields. The other exciter set consists of a driving motor, an exciter and a booster for the excitation of the generator fields in conjunction with the small direct-current auxiliary flywheel exciter. The booster armature is connected in series with the armature of the generator exciter. The field of the generator exciter and the booster exciter are in series, and are in multiple with the armature of the auxiliary flywheel exciter. The field of the flywheel exciter is excited from the main excitation source. Under normal conditions the voltage of the booster is opposed to that of the generator exciter. When the excitation current of the generator exciter is suddenly reversed, the polarity of the generator exciter is reversed and, consequently, the direction of the current in the field of the large generator. The small auxiliary machine with a flywheel, however, continues to run in the same direction for a time and thereby causes the voltage of the booster to supplement that of the generator exciter. Due to this over-excitation, the self-induction of the field current of the large generator is overcome almost instantly, so that it is possible to stop and reverse the mill motor very rapidly.

Another manufacturer uses a somewhat different scheme, utilizing indirect compounding of the main driving motor by means of an exciter and provides for a variation of the compounding effect for different main field strengths of the reversing motor, the compounding varying in the same proportion as the shunt excitation varies. A special speeding up arrangement is used to counteract the self-induction of the main generator fields. This is accomplished by the use of two field windings on one exciter, one shunt and the other compound. The compound winding is equal to one-half the shunt strength and opposes it. The design is such that at the instant of switching on, the generator field winding receives double the normal excitation voltage. This causes rapid excitation and as the excitation current increases the opposing compounding winding comes into action and reduces the excitation volts to the normal value. Also, in order to avoid a drop in the voltage of the generators, due to the slip when heavy loads occur, a compounding voltage is introduced into the excitation current of the generator. This voltage varies inversely as the speed of the generator. The generator voltage is thus made practically independent of the speed variation even up to a slip of 20 per cent.

The usual practice on all Ilgner motor-generator sets is to use automatic operation of the liquid slip regulator. This is obtained in different ways, some of which are more complicated than our practice of using a series torque motor.

Power Factor Correction

Schemes for obtaining power factor improvement are used more in Europe than in this country. Over-excited synchronous motors are used extensively for drives where applicable, but phase advancers operating in the secondary circuit of induction motors are more generally used. The advantage of the phase advancer method is that the magnetizing current is supplied at low voltage and frequency in the rotor instead of at full voltage and frequency and, therefore, the phase advancer is smaller and less expensive than the synchronous motor for a given power factor correction. Several types of phase advancers are used, none of which incorporate self-propulsion features, as are used in this country.

Switchboards

In Europe, more recently, much of the switching and metering apparatus is grouped in units enclosed in cast-iron cases rather than mounted on panels.

*Observations on Rolling Mill Drives in Continental Europe**

By O. NEEDHAM†

THE following observations were made on steel mills in Continental Europe, and tend to emphasize the differences, as well as the similarities in practice prevalent in European installations, as compared with corresponding apparatus and operations in America.

Reversing blooming mill motors of European manufacture do not present the same rugged appearance as do American-built machines. The bearings on these motors are neither as large in diameter nor as long in proportion to their diameter as they are for corresponding torque ratings in America. They do not use thrust bearings of the heavy type used in this country; in fact, they do not use external thrust bearings at all. The writer was advised that in most cases a thrust ring is forged on one journal and a groove provided in the bearing for the thrust ring to run in. This, of course, was not visible from the outside. This arrangement could not withstand any severe thrusts such as the American type of thrust bearing is designed to take care of. Some installations used specially designed couplings, which would, in themselves, take care of some end movement if the middle member should break, while other installations did not appear to have made any provision for taking care of severe end thrusts such as might be produced by the breaking of a spindle.

It was observed to be common practice to cast lugs on the bedplates of the reversing motors and machine these up to match similar lugs cast on the pinion housings. The two are then bolted solidly together. One engineer stated that he did not particularly like this arrangement, as he found that it was extremely difficult to get a job built by different manufacturers that would fit up together properly, so that they frequently had considerable trouble getting these two pieces of apparatus properly bolted together and in correct alignment.

The common practice is to operate flywheel motor-generator sets at higher speeds than in this country. Flywheel set speeds of 400 and 600 R.P.M. are very common, even on the largest sets. This makes it necessary to use smaller capacity generators and increase the number of generators to produce a given capacity. Not infrequently four generators are used on one flywheel set to drive one reversing motor. In most cases, the four generators are connected in series and give a combined voltage of about 1,500, this combination being used to drive a double armature reversing motor. In one case, two generators were operated in parallel to supply power to a single armature reversing motor. The writer was advised that at this same plant they sometimes used four generators grouped in series parallel combination to drive one single armature motor. By doing this they could supply greater capacity to the reversing motor and this arrangement also doubled the full field speed of the reversing motor.

Cast steel flywheels on flywheel motor generator sets are operated at higher peripherial velocities than are used in America. Peripherial velocities of 21,000 feet per minute being very common and velocities up to 26,000 feet per minute are used.

The practice of mounting the large induction motors and the flywheels and generators on a common bedplate is not universal in Europe at all. In fact, this arrangement appears to be seldom used. In many cases, the induction motor was mounted on one bed plate and the generators on another bedplate. The flywheel was merely mounted on its own bearings on sole-plates and the induction motor and generators were flexibly coupled to it. When four D.C. generators are used on one flywheel set, it is quite common to mount two of them on one bedplate and the other two on another bedplate. Some cases were observed where two flywheel motor generator sets were installed end to end and the two sets coupled together so they could both be operated as a single set with two driving motors and a number of generators. This would also combine the energy of both flywheels and make it all available to carry any single peak that might occur on either of the mills being operated from this combination.

The control for reversing motors differs materially from that used in this country. Contactor type

*Presented at Philadelphia, March 7, 1925.

†General Engr., Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

control is very seldom used. The method in practically universal use consists of a faceplate controller manually operated, which operates in the field of the exciter rather than directly in the fields of the reversing motor and its corresponding generators. One adjustable potential exciter is provided for the reversing motor field, another similar one for the generator fields, and a constant potential exciter used to provide excitation for the fields of the two adjustable potential exciters. The faceplate controller then operate to vary the field strength on the adjustable potential exciters and thus control the reversing motor. It is difficult to believe that this method of control can give as rapid and snappy action to the reversing motor as does the contactor type of control, acting directly in the fields of the motor and generator, such as used in America. Some articles have been published by European writers giving speed of reversal comparable to that obtained on reversing motors in this country. However, the impression gained in observing these mills in operation is that they do not accelerate and retard as rapidly as similar installations in this country.

Liquid slip regulators of various types are used to control the secondary of the induction motors on flywheel motor generator sets. This feature corresponds closely with practice in America.

The control for the primary of the induction motor, however, is somewhat different from standard practice in America. As a general thing, only one primary circuit breaker is used and no arrangement is made for plugging the motor to bring the flywheel set to a quick stop. The practice in Europe is to use a brake operating on the periphery of the flywheel when it is desired to bring the flywheel set to rest quickly. These brakes usually consist of water-cooled cast-iron shoes or else wood-lined shoes arranged so they can be brought to bear on the periphery of the flywheel by means of a large hand wheel mounted on a pedestal at the side of the flywheel set.

It is also quite common practice to provide a barring motor to start the flywheel set from rest instead of starting it with the main driving motor. This barring motor is geared to the set and arranged so that after the set is started in rotation and power then applied to the main induction motor, the barring motor will automatically be disconnected when the speed of the set reaches a certain value.

The engineers explained to the writer that the reason these last-mentioned devices are employed is that there is considerable objection to throwing such loads on the power system. They stated that while they felt that their power systems were ample to take care of the peaks which occurred during normal operation, that the sudden throwing on of a heavy load tended to disturb the system and for that reason they resorted to the above devices to prevent such occurrences.

There is a tendency to extend the use of reversing mills to other fields than blooming mills. Many rail and structural mills, as well as billet mills, of the multi-stand type, are operated two-high and reversing. These mills are driven by reversing motors and also by reversing engines.

Constant speed continuous running mills are driven by wound rotor induction motors. The construction of these motors is quite similar to that used in America, with one notable exception. The motors are made as short as possible and no provision is made to shift the stator over on the bedplate for gaining access to the rotor and stator for inspection and repairs. It is usually necessary to split the frame and remove the upper half to gain access to the rotor and stator. Mechanically, the induction motors appear to have about the same rugged construction as used in America.

In going through European mills for inspection, the impression is gained that a larger percentage of the motors are direct connected to the mills than is the case in this country, although many geared installations were observed.

Induction motor control is similar to that used in America except there is probably a larger percentage of manual control used than in this country. For the secondary control of induction motors with which flywheels are used, the three common types, namely, permanent slip resistance, notch back and liquid slip regulators, are used. The use of liquid slip regulators and liquid starters is more general than in this country, particularly liquid starters. Many drives that do not employ a flywheel at all use liquid type secondary controllers. In many cases, these are hand-operated and a device to short circuit the leads from the slip rings of the motor is provided in the liquid starter.

A much smaller percentage of constant speed induction motor drives are used than in this country. In other words, a very high percentage of the mills are equipped with adjustable speed drives. This is possibly due to the fact that most of the European mills are much more of a jobbing proposition than here. It is necessary to change section frequently and also to roll a very wide variety of sizes on a single mill, and for this reason adjustable speed driving units are necessary.

The predominating type of adjustable speed drive is the direct current motors. Some alternating current adjustable speed drives of the Scherbius or Kraemer type are used, but the D.C. motor very largely predominates. Speed adjustment is obtained by shunt field control. The D.C. motors used have about the same rugged construction as used in this country. In fact, the D.C. motor resembles more nearly its counterpart in America than does any other type of rotating electrical equipment.

Where alternating current is generated it is converted to direct current by motor-generator sets, rotary converters, motor converters, and even Mercury rectifiers. The two latter methods mentioned are new to America.

The motor converter is a type of rotary converter with a physical resemblance to a motor-generator set. The driving unit is a wound rotor induction motor. The primary of this motor is connected to the power system at line voltage, provided the line voltage is not over 10,000. Taps are carried from the secondary or rotor winding through the middle bearing by means of a hollow shaft and tapped into the rear of the D.C. armature. This machine has similar characteristics to a rotary converter and takes primary power direct from the system without transformers, provided the primary voltage is not greater than about 10,000 volts. This type of machine is not in general use and does not appear to be a serious rival of the well-known M-G set or rotary converter.

One installation consisting of six 500 KW. Mercury rectifiers was observed. However, this instal-

lation was not complete and none were in operation, so that no data was available. This installation was designed to supply direct current at 500 volts.

The D.C. voltages used commonly throughout the mills vary from 250 volt installations up to 500 volt installations, with the 500 volt installations predominating. The direct current systems in practically universal use in this country are 250 volts. However, it was observed that 500 volt installations are very common in Europe and this voltage is used on their main driving motors as well as on all of their direct-current auxiliaries. In fact, where alternating current auxiliaries are used extensively, the common practice is to operate these from a 500 volt circuit, also.

For auxiliary drives they have enclosed mill type motors similar in construction to those built in America, except in some cases they are not quite so rugged. A.C. auxiliary motors are used to considerably greater extent than in America, and in most cases where they were used the engineers stated that they were well satisfied with them. However, this satisfaction with A.C. auxiliaries was not universal, the general preference there, as in this country, is for the use of direct current auxiliaries and all users of D.C. auxiliaries expressed satisfaction with them.

The use of magnetic control on auxiliaries is not as general as in America, but there seems to be a growing preference for the use of magnetic control, and it is largely used on new installations.

Most of the European steel mills generate all or the greater part of their electrical power and this is done largely by the use of gas engine-driven generators. In many cases a steam turbo-generator unit is used as an auxiliary to take care of the swings in load. The A.C. voltage used on main-drive motors varies from 2200 volts up to 5000 or 6000 volts; 50 cycles is practically the "universal frequency. Most of the steel mills generating stations are of moderate capacity, but some of them have generating stations totaling upwards of 50,000 Kv.-a.

Some observations on the mills themselves might be of interest. With reference to the practice on the mills themselves, it can be stated that in general, it is about the same as in this country, except that they do not have large orders of a single product, so that, as a rule, the tonnage produced on a similar mill is less than in this country. The use of mechanical loopers or repeaters on merchant and rod mills appears to be developed farther than in this country. In one case observed looping guides were provided on the roughing stands of a rod mill to repeat the bar back after the first pass. The billets used were 70 millimeters, or about 2¾" square and about 4 feet long. These entered the two-stand rougher automatically, and were mechanically looped through the three-high roughing stand and out through the two-high bull head on through the three-stand two-high intermediate train. Catchers were located on one side of the second intermediate and finishing train, the same as is done in this country.

Two installations of soaking pits in which no fuel was burned were observed. The ingots are stripped as soon as they solidify sufficiently and placed in these pits, where the internal heat of the ingot redistributes itself, so that the ingot becomes uniformly heated. It is then removed and rolled into finished beams, rails, etc., all from the original heat from the converters.

The observations given on mill practice in Continental Europe apply practically in total to England, Scotland and Wales. England, perhaps, has a greater percentage of plate mills compared to other types of mills than any other country. This is probably due to the fact that England builds so many ships.

When mention is made in this article of mill practice in England it is understood that England, Scotland and Wales are meant and also that the more modern mills are referred to.

Blooming mill practice in England is similar to that in this country, in that they roll similar sizes of ingots to similar sizes of blooms and slabs. In most cases, however, the tonnages produced are smaller on a comparable mill than in America. However, one or two blooming mills were observed in which the tonnage compared quite favorably with similar mills in this country.

Their blooming mills themselves do not compare directly with ours for the reason that they use larger roll diameters, as a general practice than is done in America. When they mention a mill size they usually refer to the roll diameter instead of the pinion diameter. For instance, a 40" mill would mean a mill having 40" diameter rolls and this would be a larger mill than a so-called 40" mill in this country. However, the work done on such a mill would be about the same as in America and the tonnage produced would be less than in this country. As a rule, they do not use reversing motors with as high a continuous rating as on similar mills in this country. This is logical when it is considered that a smaller tonnage is produced. The reason for the smaller tonnage is that they do not have large orders for a single product, such as is the case in America.

The practice on flywheel motor-generator sets, and flywheels, in England, as on the Continent, is to use higher speeds than in this country, and then use three or four generators in series to obtain the necessary capacity.

Some recent tire mills' electrifications were inspected which were very interesting. These mills were used for the production of locomotive tires, etc. Some consisted of two rolls separately driven by adjustable speed direct-current motors. Others, where only one roll was power driven, used wound rotor induction motors for main drives.

Sheet Bar, Billet and Structural mills are operated non-reversing, as a rule, but a number of multi-stand mills of this type are operated reversing, in which case a regular reversing equipment using Ilgner set and Ward-Leonard control is used.

For Hoop and Band mills, and also for Merchant mills, where adjustable speed is desired, the use of direct current adjustable speed motors, Scherbius sets and Kraemer sets is resorted to. The tendency, however, is toward the use of straight adjustable speed direct current motors.

The direct current where not generated in the plant is converted from the alternating current by rotary converters, motor-generator set, and motor converters. The latter were mentioned before in this article in connection with Continental steel mill practice.

Until quite recently the practice in Sheet Mill drive was somewhat different from that in this country. There has been a general reluctance on the part of English operators to adopt the use of comparatively

high speed motors with gear units to drive sheet mills. Their practice was to use relatively slow speed motors and connect them to the mill through rope drive. Their reason was that they feared that the use of gears would result in a marking of the surface of the sheets due to vibration caused by the gear teeth. English engineers are familiar with the fact that the drive now used almost universally in this country is a high-speed motor and a herringbone gear unit with flywheels overhung on the pinion shaft. They know, also, that the results obtained here do not justify their fears as to the marking of the sheets, so that on some of their new installations they are willing to consider the use of a geared drive.

Plate mill practice in England differs more from that in America than for any other type of mill. In the first place England has been somewhat reluctant to adopt the three-high type of plate mill. Their standard type, until comparatively recently, consisted of a two-stand, two-high reversing mill. The slab was roughed on the first stand and then the final or bull head pass was made on the second stand. It was felt that no other type of mill could produce as good a plate as this type. They felt that the rolls on the second stand, which was used for the finishing pass only could be kept in better condition and therefore would produce a better plate than if a three-high mill were used and all passes were made with the same rolls. This opinion is changing somewhat, due to the success which has been obtained in America with the three-high plate mill and several three-high plate mills have been installed, and are entirely successful.

It might be of interest to mention here that there is a comparatively recently installed three-high plate mill located in Scotland, using a reversing type of direct current motor connected direct to the Lauth pinion housing and supplied with power by a flywheel motor-generator set. The drive itself is identical with a reversing blooming mill equipment. Ward-Leonard control is used. There is, of course, no flywheel on the mill itself. The writer was advised that this type of drive was decided upon after a careful study was made of the various methods which might be used. It was stated to the writer that the initial cost of this drive was not as much greater than that of a standard drive as might at first be supposed. The contention was that the decreased cost of flywheel on account of the higher speed at which it was operated on a flywheel set accounted for this fact. The standard drive consists of a constant speed induction motor and the flywheel on the mill.

It is believed that the direct current drive mentioned above, must have been compared with a slow speed motor and direct connected flywheel, because, undoubtedly a high motor and flywheel geared to the mill would have been much cheaper. However, the direct current drive outlined above has advantages over a constant speed drive which, in a measure, may justify its use in some cases. The mill can be operated at any desired speed up to the maximum and it can also be changed in speed while operating under load at any time. In fact, this latter feature had considerable weight in the decision to adopt this drive. The mill can be slowed down to enter large slabs and operated at comparatively slow speeds during the roughing passes and then speed up to make the finishing passes, thus considerably increasing the tonnage output. Then, when rolling light material the mill can be operated at high speed at all times.

Two plate mill installations were observed in which magnets were used extensively to handle plates. At one place the "drag over" on the hot beds consisted of electro magnets, instead of "dogs," carried on cables. The cable drums were motor-driven. This arrangement was highly satisfactory as a plate handling scheme, but I understand the "mortality" of magnet coils was rather high due to the heat from the plate. The other installations used magnet-operated "dogs" instead of magnets acting directly on the plate. This prevented burn-out of the magnet coils by making it possible to locate the coils farther away from the plate, so that a more satisfactory life was obtained from the coils.

The use of special magnet type of plate handling cranes is quite common, some of these being very ingenious and apparently very successful. They are arranged with two or three magnets mounted on the under side of a heavy cross arm which is suspended from a crane. In the three-magnet type the middle magnet is stationary in the center of the cross arm. The other two magnets are supported by the arm, but connected to a threaded rod running the full length of the arm. One magnet by a right-hand nut and the other by a left-hand nut. This threaded rod can be rotated by a small motor which runs the two movable magnets away from the center or toward the center, depending on the direction the rod is rotating. Thus the magnets are adjusted for any desired length of plate. The cross arm can be rotated in a horizontal plane to turn a plate in the desired direction. All control is in the hands of the crane operator, so that one man can handle the entire apparatus.

Another very interesting device is the so-called "Ennis" patent machine for plate shearing. This machine consists of a car operating on a standard gauge track which runs along by the side of the side-cut shear. This car is arranged with two parallel live roller lines, each line separately driven so that they can be operated together or one at a time and also so that one line can be operated forward while the other is operated reverse. This feature is for turning a plate around on the car. About one-quarter distance from each end of the car there is located a traveling magnet arranged to travel across the car on a lathe bed. A threaded rod propels the magnet by means of a traveling nut, and this rod is driven by a motor which can be operated in either direction. These two magnets are used for locating the plate laterally on the car. This machine can be traversed as a whole up to the receiving point or the end of the mill live rollers, when, by operating the roller bed on the machine itself, the plate is drawn into position. It is then moved into place for cutting by the magnets which slide across on lathe beds between the rollers. The magnetic force is sufficient for clamping the plate even without the help of the hydraulic holding-down gear on the shear. It is stated that very rapid handling of the heaviest plate is secured and great economy can, of course, be effected by doing away with the enormous expensive labor methods employed in the old system. The shear, as stated above, is located at the side of the track, the entire control of the table is in the hands of one operator located on the car and at some places this same operator controls the shear clutch for making the cuts. In some cases, both sides of the plate are sheared on one shear, the plate being turned by operating each side of the roller bed in opposite directions. In other cases, a shear is provided on

each side of the track and in still others, two "Ennis" tables are used on the same track. The first operator, after shearing one side of the plate, delivers it to the second operator, who shears the other edge with the second shear on the opposite side of the track.

For driving auxiliaries they have mill type motors similar to those in use in this country. Several installations use alternating current auxiliaries entirely and the operators expressed satisfaction with them. In most cases, however, the use of direct current auxiliaries is the more common and the tendency is toward the use of direct current auxiliaries.

Contactor type of control is in quite general use and the tendency is toward its even more general use.

One rather interesting control feature was the limited use of Eddy current secondary controllers for auxiliary wound rotor induction motors. The Eddy current starter has no moving parts, it takes advantage of the fact that the secondary frequency is the same as the line frequency when the primary is energized with the rotor standing still, and that the secondary voltage and frequency gradually reduces to zero as the rotor approaches synchronous speed. These starters have operated to the satisfaction of their users on some applications, but one English writer makes the following statement regarding these starters:

> "A number of tests on these starters taken over a considerable time has, however, shown, that the Eddy current rotor controller has its limitations, namely, in the dissipation of heat generated by the induced current in the core. It works admirably where the number of reversals does not exceed five or six at the most per minute, and are excellent for the approach rolls to the live rolls, to shears, etc. But when this number of reversals is exceeded the heat generated exceeds the heat lost by radiation and the cores and coils can easily become red hot, and no means has yet been found to remedy this."

In going through the steel mills in England the impression is gained that considerably more manual labor is employed around the mills than is the case in this country, and English operators are working on schemes to cut down the amount of manual labor required around the mills by installation of automatic and electrically-controlled devices.

The question of a method of obtaining electric power for use in steel plants in England is fairly well covered in the summary of an article by an English writer, from which the following is quoted:

> "In steel works, where blast furnaces and coke ovens form part of the plant, the availability of large quantities of surplus gas call for a power station as an integral portion of the plant. It is not possible to refer to any large developments in this direction which have taken place during the past year, but the necessity of making full use of the heat available renders the installation of gas engines practically certain, except in such cases where the gas supply is more than ample for the power requirements, when gas-fired boilers and steam turbines are likely to be adopted. The reliability of the present-day large gas engines has removed the prejudices hereto felt for this form of prime mover, and the realization of the importance of providing clean gas to a gas-engine plant will insure successful operation in the future. At the same time, it must be admitted that the comparatively small size of gas engine built—the largest unit approximating to 4,000 H.P.—acts as a deferrent in a large steel works, where, possibly, 40,000 or 50,000 Kw. of electrical power is necessary, and it remains to be seen whether it will be possible and satisfactory to increase the size of units in the future."

*Grounding The Neutral**

By EDGAR D .SIBLEY†

Filter for No. 5 Generator—Neutral

THE growth of the power system of the Metropolitan Edison Company during the last few years has made it desirable from an operating standpoint, to ground the neutral of the 13,200-volt generators at the West Reading Power Station. This is in line with the general practice of large power stations all over the country, since it simplifies the method of selective relaying and reduces the magnitude of voltage surges and therefore the stresses on generators and cables.

Immediately after grounding the neutral of one of the generators known as No. 5, the Pennsylvania Railroad experienced a very severe noise interference on their dispatching circuit between Reading and Philadelphia. This complaint led to an analyzation of the wave shape of the current flowing in the ground leg of this generator.

Oscillograms, which were taken by the Westinghouse Electric and Manufacturing Company, of the line-to-line and line-to-neutral wave form of the generator both at no load and partial load showed that the wave forms were very good, and the higher harmonics which were liable to cause telephone interference could not be found, as they were less than ½ of 1% (instrument error). The following harmonics were, however, present in the ground current:

GROUND CURRENT

Harmonic	3rd	9th	15th	27th	33rd	39th
Amperes	1.00	1.68	2.48	.37	2.00	.55

In star connected generators whose neutrals are not grounded, triple harmonic voltages between line and neutral are of practically no consequence, but when the generator neutral is grounded the triple harmonic voltages are all in phase and may result in a current flow in the ground leg of considerable magnitude. This theory was substantiated by actual facts in this particular case, as may be seen by a study of the results of the oscillograph tests described above. If it so happens that a transmission line connected to the generator is of such length

*Presented at Philadelphia, April 4, 1925.

†Engr., Metropolitan Edison Co., Reading, Pa.

as to be resonant at any of the frequencies which are present as harmonics in the generator voltage, the harmonic current which flows will magnify the small harmonic voltage in the generator by 10 to 25 times at some point out on the system.

It is a well-known fact that electricity travels about 180,000 miles per second, which corresponds to 3,000 miles during 1-60th of a second or one cycle. Resonance takes place at one-fourth wave length, or 750 miles at a frequency of 60 cycles. The lengths of lines required for resonance at higher frequencies decrease in direct proportion to the increase in frequency. For example, a 50-mile line is resonant at the 15th harmonic (900 cycles) and a 23-mile line is resonant at the 33rd harmonic (1980 cycles.)

In the case of which I speak the Pennsylvania Railroad is closely paralleled by a 13,200 volt transmission line for about 8 miles. The power and

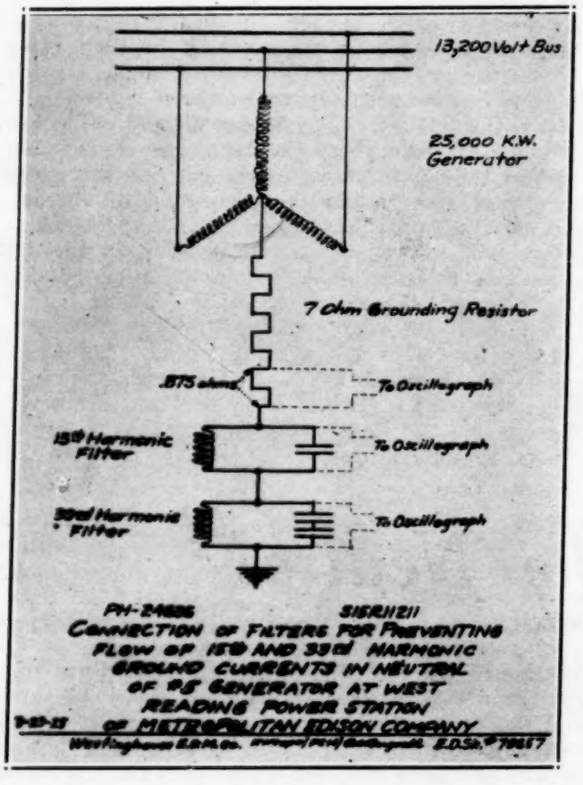

13,200 Volt Bus
25,000 K.W. Generator
7 Ohm Grounding Resistor
To Oscillograph
To Oscillograph
To Oscillograph
PH-24636 SIERIIZII
CONNECTION OF FILTERS FOR PREVENTING FLOW OF 15TH AND 33rd HARMONIC GROUND CURRENTS IN NEUTRAL OF #5 GENERATOR AT WEST READING POWER STATION OF METROPOLITAN EDISON COMPANY

FIG. 1

telephone lines are not transposed with respect to each other, but no trouble from inductive interference was experienced as long as the neutral of the generator was not grounded. There is a 15-mile transmission line from West Reading to Ringing Rocks, at which point the line divides into two branches, each approximately 18 miles in length, extending to Norristown and Freidensburg, respectively. From these distances it may be seen that the lines are of such length that they may resonate at the higher frequency harmonics of the generator.

The 3rd, 9th and 39th harmonics are well out of the range of voice frequency and were, therefore, eliminated from consideration as a source of noise. The magnitude of the 27th harmonic current was so small that it was not considered to be a large factor in the noise.

It was concluded that the interference situation would be materially improved if the flow of 15th and 33rd harmonic ground currents could be prevented. This would reduce the high frequency voltage induced in the telephone lines; first, by eliminating the electro-magnetic induction due to the high frequency current returning through the earth; second, by preventing the harmonic voltages in the machine from being magnified between line conductors and ground due to resonant conditions existing out on the system.

In order to reduce these currents, two filters were designed (by R. C. Bergvall of the Westinghouse Electrical and Manufacturing Company), each filter consisting of an inductance paralleled by a

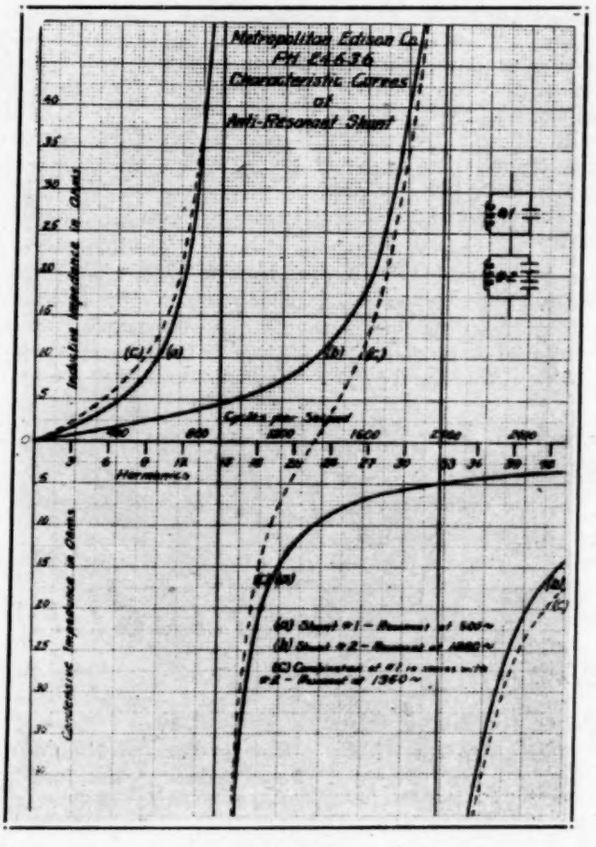

Metropolitan Edison Co.
PH 24636
Characteristic Curves
of
Anti-Resonant Shunt
Harmonics
Cycles per Second
(a) Shunt #1 – Resonant at 900~
(b) Shunt #2 – Resonant at 1980~
(c) Combination of #1 in series with #2 – Resonant at 1360~

FIG. 2

condenser. One of these filters was designed to be resonant at a frequency of 900 cycles and the other designed to resonate at a frequency of 1980 cycles, these frequencies being the 15th and 33rd harmonics, respectively, of a 60-cycle wave. Standard oil filled static condensers such as are used for power factor correction were connected in parallel with the inductance coils. The capacities of these condensers were carefully measured and the size and number of turns required for the coils were calculated. The coils were then constructed with some additional turns, which were removed one turn at a time until the proper balance was obtained with the coil and condensers in parallel across a source of high frequency, thereby obtaining a close balance. When

the 15th harmonic filter was tested, about 3-10 of an ampere input resulted in 7 amperes circulating between the inductance and the condenser, which shows that the filter was very effective.

The ground current, which can flow in the neutral leg of the generator, is limited to about 1,000

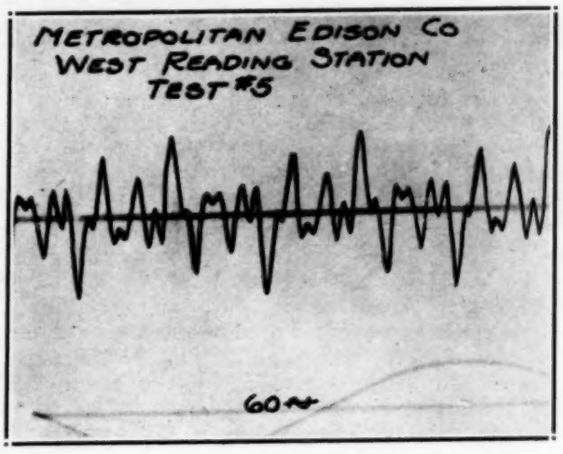


FIG. 3

amperes by a current limiting resistance in series with these filters. The conductors on the inductance coils were made large enough to carry the 1,000 ampere ground current for one minute without excessive heating, thus giving the circuit breakers time to clear the line in trouble. The conductors were made of cable containing a large number of strands of No. 24 copper wire, as it was felt there might be sufficient eddy current loss at the high frequencies to reduce the efficiency of the filters. The conductors were vacuum impregnated with a

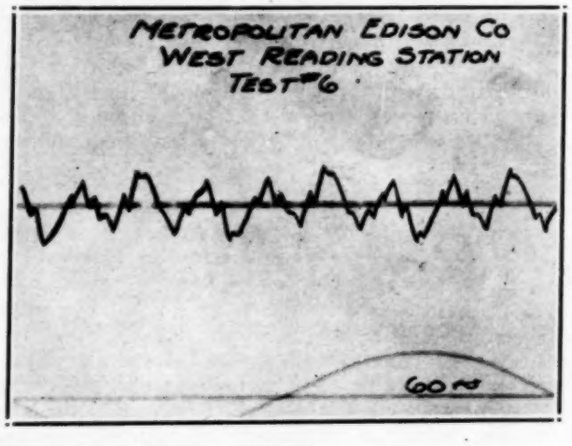


FIG. 4

heavy gum in order to reduce eddy current losses. However, from experience gained on preliminary tests with standard reactors having heavier conductors, it is believed that the eddy current loss is not a large factor.

The 15th harmonic filter consisted of 62 turns of 105,000 circular mil cable composed of 259 strands of 24 B. & S. copper wire. This cable was wound on a nicarta tube, 20 inches outside diameter and 23 inches long. The 60-cycle impedance of the filter is .563 ohms and the direct current resistance is .03387 ohms. The capacity of the condenser was approximately 20 micro farads.

The 33rd harmonic filter consisted of 53 turns of similar cable wound on a micarta tube, 13.5 inches outside diameter and 20 inches long. The

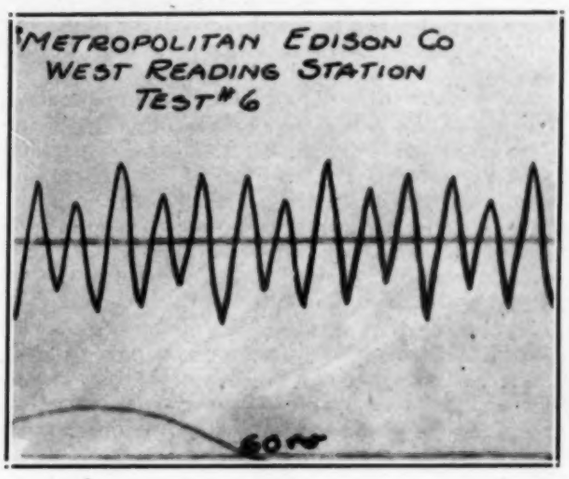


FIG. 5

60 cycle reactance was .236 ohms and the DC resistance .0214 ohms. Two standard 20 micro farad condensers were connected in series to obtain the 10 micro farads required for parallel resonance.

Resonance in Oscillating Circuits

Since the reactance of an inductive circuit is directly proportional to the inductance (expressed in "henries"), that is, since

$$X_l = 2\pi fL$$

and since the reactance of a capacitive circuit is

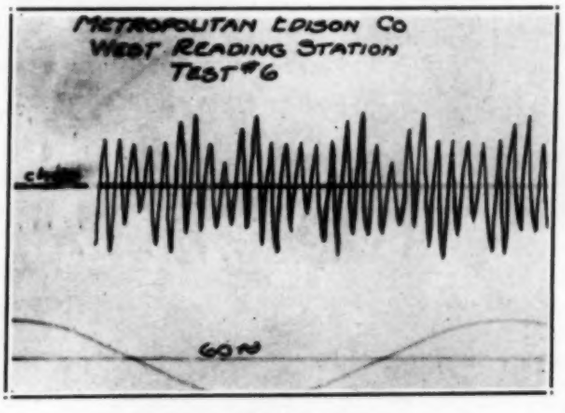


FIG. 6

inversely proportional to the capacitance (expressed in "farads"), that is, since

$$X_c = \frac{1}{2\pi fC}$$

then for every oscillating circuit made up of a definite inductance and a definite capacitance, there is a corresponding definite frequency for which the inductive reactance is exactly equal to the capacitive reactance, that is, the sum of the inductive reactance and the capacitive reactance is equal to zero. Under

these conditions, the only remaining factor which opposes the flow of current through the circuit is the ohmic resistance, the magnitude of the current flow is a maximum and the circuit is said to be in resonance.

The curves marked "A" on Fig. 2 show the variation of the inductive and capacitive impedences with frequency, of the reactance coil and the condenser which make up the filter used to suppress the flow of the fifteenth harmonic current in the ground leg of the generator. These impedence values, of course, include the resistance of the particular parts of the circuit in question. If curves had been drawn showing simply the inductive and capacitive reactances (not including resistance) of the reactance coil and condenser, it would have been found that these two curves would have crossed the 900 cycle line at equal distances from the frequency axis. The algebraic sum of this inductive reactance and capacitive reactance is, therefore, equal to zero—and the oscillating circuit is resonant at that frequency. The same conditions are true in the case of the filter for the thirty-third harmonic, however, at a frequency of 1980 cycles.

It is plain to be seen that when two of these oscillating circuits are connected in series (the two circuits being resonant at different frequencies), the resultant impedence of one of the circuits at a particular frequency will be on the inductive side, while that of the other circuit at the same frequency will be on the capacitive side. There will, therefore, be a frequency for the series combination at which the resultant inductive reactance of one of the circuits will be equal to the resultant capacitive reactance of the other circuit, thus making the resultant reactance of the combination equal to zero and bringing about a resonant condition. The frequency at which this condition will obtain will be at some frequency other than that at which either circuit is in resonance individually.

The dotted curve "C" shows the algebraic sum of the inductive and capacitive reactance respectively of the two filters mentioned, for different frequencies. This curve is seen to pass through the zero point at a frequency of 1360 cycles, 23rd thus indicating a resonant condition of the combination at that frequency. This frequency is not present in this generator and, therefore, the condition has neither harmful nor helpful effects. It is of interest to note, however, that a combination of two oscillating circuits of different resonant frequencies can be made to apply as a filter at three frequencies if the constants of the circuits are correctly chosen.

Fig. 3 shows the current in the neutral resistors without the filters. This ground current when analyzed showed the presence of the 3rd, 9th, 15th, 27th, 33rd and 39th harmonics, as previously mentioned.

Fig. 4 shows the ground current with the same oscillograph calibration after the two filters were put in service. From an inspection of the film it may be seen that there is a small amount of 3rd, 9th and 27th harmonic present, but the 15th and 33rd harmonics which predominated on Figure No. 3 have been eliminated. The elimination of the 15th and 33rd harmonics by the use of these filters succeeded in reducing the interferenc to such an extent that it was no longer noticeable.

Fig. 5 shows the 15th harmonic voltage which has been "piled-up" across the 15th harmonic filter. At the time the test was made this voltage amounted to 75 per cent of the voltage to neutral.

Fig. 6 shows the 33rd harmonic voltage across the 33rd harmonic filter. The magnitude is about 25 per cent of the voltage to neutral.

In another test the 15th harmonic current was allowed to flow, by taking the 15th harmonic filter out of service, and the 33rd harmonic was still blocked out. The shrill note corresponding to 900 cycles was plainly heard in the telephone lines.

At another test the 15th harmonic current was blocked out and the 33rd harmonic allowed to flow. A moderate amount of noise remained and the telephone lines could, undoubtedly, have been successfully operated without the 33rd harmonic filter in service, but it was thought best to completely eliminate the noise and leave both filters in service.

Orientation of Steel Rod Mills

By GUERNSEY H. COLE†

Temples vs. Steel Mills

ANCIENT Grecian temples and many modern churches were carefully oriented by their designers so that the main entrance faced the East or so the altar was in the eastern end. Considerable attention was also given to orientation of the pyramids. It probably has never occurred to steel-mill men that it is of commercial importance to orient steel-rod mills; yet in some instances at least, considerable trouble would have been avoided if the major axis of the mill had been laid out perpendicular to the magnetic meridian. The reasons presented in this article, which make orientation of rod mills desirable, are quite different, of course, and more practical than those which governed the erection of temples. The experiences recounted are those which have been encounterd in steel mills. Some laboratory tests made for benefit of steel mills are also reported.

Annoyance of accidental magnetization

In machining operations, magnetized steel is a nuisance, as small turnings or chips adhere to the machined surfaces. In quantity production, it is generally desired to buy the raw material of a size close to the finished dimensions and to make a very light machine cut. The small turnings and chips which result from this operation are especially objectionable when magnetized steel is used for drive shafts or axles, as it

†Engineering Department, Westinghouse Electric & Mfg. Co.

is very difficult to free the parts from minute steel particles which will cause abrasion of the bearing if not removed.

Factors Favorable to Permanent Magnetism

Factors which tend to cause high residual magnetization in steel rods are:

(a) A high ratio of length of rod to its diameter.
(b) Hard steel.
(c) A strong magnetizing force.

Rods having a length equal to 200 times their diameter are easily magnetized. Even a ratio of 20 to 1 will cause considerable trouble if other factors are favorable. Steel used for high grade axles, drive shafts and tools are very apt to have chemical composition suitable to the retention of magnetism. The important chemical elements of such steels may be: high carbon, carbon-tungsten, carbon-cobalt, chromium-tungsten, or carbon-chromium.

Strength of Magnetic Field

The magnetizing force produced by 10 amperes flowing through a 100-turn solenoid, 30 inches long, may magnetize an annealed high carbon or alloy steel rod, say 5 feet long and 1 inch in diameter, sufficiently to cause trouble. If a steel rod such as described above, which we will designate as rod No. 1, were subjected to vigorous mechanical working while in a magnetic field which is only 1% as strong as that in the solenoid, it will be magnetized to a degree similar to that attained when it is held undisturbed in the stronger field. This weak magnetic field would correspond to the magnetic field of the earth. The intensity of the earth's magnetic field generally is found to be between 0.15 and 0.3 metric units. It varies from year to year and with geographical position. A value slightly below 0.2 is common in the United States. This is a field similar in strength to one produced in a very long solenoid carrying 0.4 ampere-turns for each inch of its length. Few engineers are aware that such a weak field need be considered in making plans for the erection of steel mills.

Permanent Magnetism Produced in Straightening Machines

If the steel mill is laid out along a north and south direction, it is very probable that straightening machines would hold the rods in this same direction. As the rods are generally subjected to stress beyond the elastic limit in these machines, long rods very probable will be strongly magnetized if they have a suitable chemical composition and will retain their magnetism tenaciously. For example, the magnetism in the rod No. 1 referred to above, was reduced less than 2% by rotating it through 180° from the position, with reference to the earth's field, in which it was held when originally magnetized. Of course if it were subjected to severe stress in the new position the original magnetism would disappear and a magnetic state of opposite polarity would appear. The magnetism of rods of this character is not reduced sufficiently, over periods of several days at least, to remove, by ageing, the annoyance of magnetism.

Permanent Magnetism Produced in Quenching Operation

If quenching operations are carried out while rods of proper chemistry are held in a vertical position, or are not approximately perpendicular to the magnetic meridian, it is quite probable that the permanent magnetism acquired during this operation, also, would be high enough to be troublesome.

Cumulative Magnetic Effect

In a rod mill it is convenient to pile up the rods emerging from the straightening machine or quenching tank at a point close to the machine until a load of sufficient size has accumulated. These piles of magnetized rods superimpose their magnetic field upon the earth's field usually so as to produce a stronger magnetism in the rod which is being straightened or hardened. The continual production of magnetized rods under such conditions results in very strongly magnetized rods. These in turn magnetize all the steel equipment, such as storage racks and steel cars and even the building itself. Finally a condition is reached such that it is difficult to find a piece of steel in the mill that is not magnetized to some degree, even though it has not been subjected to stress while in a north and south position. This frequently resuits in factors other than the earth's magnetism being blamed for the conditions. The trouble is sometimes ascribed by millmen to motors, electrical circuits or to electromagnets even though the latter handles no material after it has been heated above the non-magnetic point. (Ar2.)

Intensity of Magnetization

By the cumulative effects described above, rods having a maximum flux density of over 1200 gausses (7750 magnetic lines per square inch) have been produced in the course of regular production. Some comparisons may assist in understanding this statement. A rod magnetized to this degree will affect a compass held 18 inches from the rod. A short coil placed at the center of a similar 5-foot unmagnetized rod required 15000 ampere turns to produce an equally strong permanent magnetism, as determined by crude mill tests. A maximum flux density of only 100 gausses in steel rods will cause iron filing to adhere to the magnetized steel. A crude but convenient means of testing for permanent magnetism is an iron paper-clip suspended from a string. The attraction for a paper-clip becomes noticeable with a density of about 200 gausses and at 600 gausses it is strong enough to support one end of the clip when the opposite end is supported by the string.

Elimination of Accidental Magnetization

The best method of eliminating the annoyance of accidental magnetization in steel mills which are now in operation and which are improperly oriented seems to be the use of demagnetizing apparatus. It is, generally, not feasible to eliminate it by annealing, as this process may spoil the physical characteristics of the steel. This method may be used, however, in eliminating the magnetism of structural parts of the mill, such as steel rails, that are used in rod racks. It is not feasible to pass the rods through d-c neutralizing coils as they emerge from the place where they acquire permanent magnetism. If the field of the neutralizing coil is more than enough to compensate for the earth's field, it will magnetize at least a portion of the rod. If it is equal in strength to that of the earth's field, it will have but little influence a short distance from its end. It is generally not feasible to surround the entire machine or location in which the steel acquires

magnetism by a coil, as this would interfere with the use of a crane, or would be too expensive.

Demagnetization.

A-c demagnetizing equipment has been designed which will eliminate all annoyance from magnetism in less time than that in which it was acquired. Care is exercised to prevent the formation of a series of magnetic poles along the length of a rod during the demagnetizing process, as there may be sufficient magnetism left under this condition to cause trouble even though it is of less magnitude. The frequency of the reversal of magnetism must be sufficiently high to permit speedy demagnetization and yet it must be low enough to permit the demagnetizing effect to extend to the axis of the magnetized piece. Failure to use the proper frequency accounts for the lack of complete success to some demagnetizing equipments. The proper frequency depends upon the dimensions of the steel, its permeability and electrical resistivity. Precautions must be taken to insure the use of sufficient initial demagnetizing force and its reduction by increments which are sufficiently small.

Declination.

The necessity of such demagnetization can be avoided in new mills by careful orientation of the mill equipment with reference to the earth's magnetic field. The need for accuracy in orienting the equipment is indicated by the fact that the horizontal component of the earth's field has 10% of its maximum strength in a position differing by 84° from the magnetic north. The declination of the earth's field may result in a field of this strength even in a true east and west position. It is rather interesting to note that even though a mill were properly oriented when new, at the end of 100 years, the secular change in the declination may result in a magnetic field equal to 10% of the maximum horizontal component of the earth's field. Due to the cumulative effects mentioned above, this might produce appreciable permanent magnetism in steel rods.

The Super-Synchronous Motor

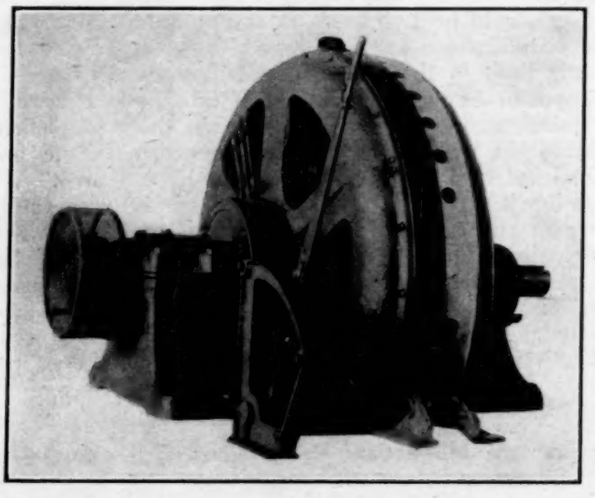
By H. C. UHL*

THE super-synchronous motor is a synchronous motor so arranged that the full pull-out torque is available for starting. This makes it possible to start loads that require a high value of torque for acceleration, and still retain the desirable characteristics of the usual type of synchronous motor, thus making it possible to extend the use of synchronous motors for applications where heretofore it was not possible to use this type of motor.

Electrically, the super-synchronous motor is identical with the usual type of synchronous motor of the same rating. Mechanically, this motor differs from the usual type of synchronous motor in that the armature, which is ordinarily the stationary member, is also arranged to rotate and a mechanical brake is supplied to control this rotation. Suspension of the armature is obtained by the use of hollow journal extensions on the end shields, which are carried by bearings at the inner end of the standards containing the motor shaft bearings. Both stator and rotor bearings are of the self-aligning, oil ring type. The periphery of the armature frame is machined for a braking surface and is fitted with a band brake which is usually operated by a hand lever. Current is taken to the armature windings through collector rings which are normally stationary. The usual collector rings are also used on the field member.

Since the motor is started and synchronized before the load is applied, it may be designed with the best operating characteristics, high efficiency, etc., whereas synchronous motors designed to start heavy loads without the use of some form of clutch frequently must be a compromise design.

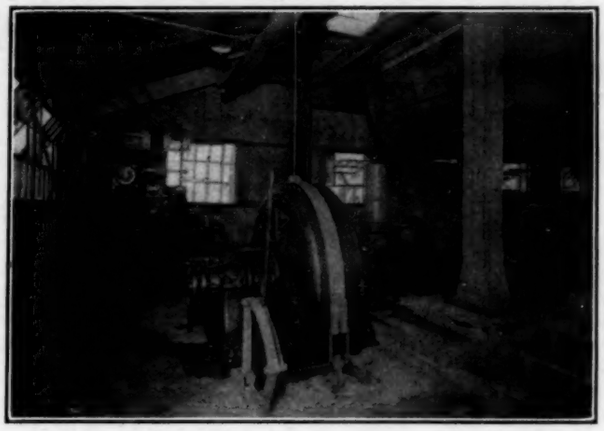
For starting, the brake is released. The rotating field, as in the usual type of synchronous motor, is connected to the load. When the armature is energized, it comes up to speed corresponding to induction motor speed. The field (rotor) is then energized and the armature comes to synchronous speed. This method of starting is similar to the method used on the ordinary synchronous motor. When the brake is applied to the rotating armature, the armature slows down and the field (rotor-connected to the load) now speeds up. Acceleration of the field (rotor) now proceeds to synchronism proportionately as the armature is brought to rest, the sum of the speeds of both members in this case being synchronous speed. When the armature comes to rest, the brake is locked and the motor operates as a normal synchronous motor.



Type ATI—40 pole—500 HP unity PF—180 RPM—2300 volt super-synchronous motor.

*Industrial Engr., General Electric Company, Schenectady, N. Y.

Throughout the acceleration of the field from zero to synchronism, the motor is able to exert a torque of much greater value than its normal full load torque. The current during starting of the load bears the same relation to the full load current as the starting torque



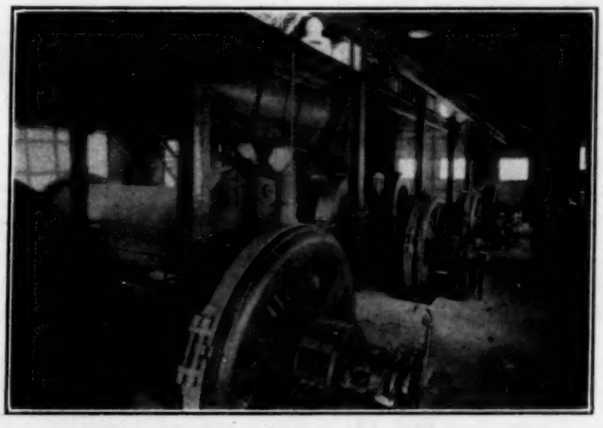
Type ATI—40 pole—250 HP—0.8 PF—180 RPM—2200 volt super-synchronous motor with automatic control, driving a Tube Mill in a Cement Plant.

required bears to the full load torque; in other words, a starting torque of 125% of full load torque will draw 125% of full load current from the line.

Owing to the mechanical arrangement, it is not possible to use direct-connected exciters for the excitation of the super-synchronous motor fields and, if direct current is not available in the plant where the motor is used, a small high speed motor generator is used to supply the excitation. This exciter set may frequently be used to supply the excitation for several motors.

The control may be arranged to start the motor by hand controlled devices or by automatic devices, as on the usual type of synchronous motor.

The super-synchronous motor is especially suited for application to all types of loads where the synchronous motor can be used to advantage and where

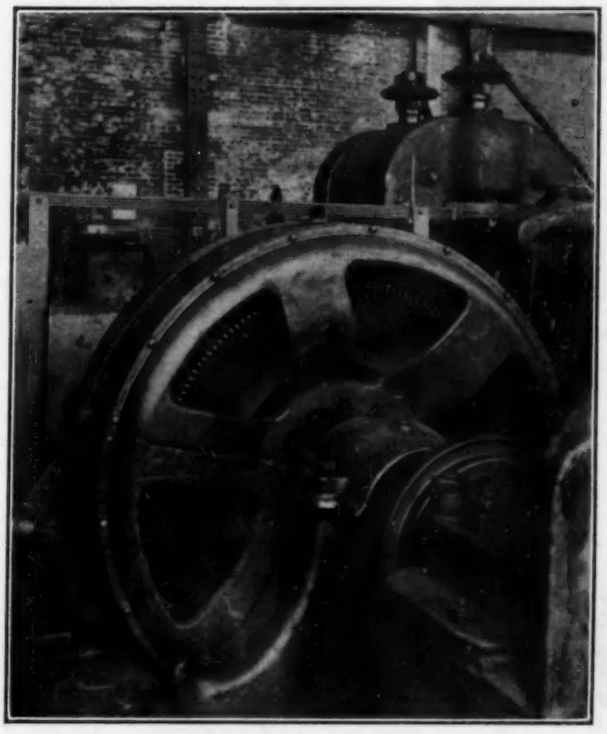


Super-synchrouos motors— (2) Type ATI—50 pole—125 HP—0.8 PF—144 RPM—2200 volts, driving Kominuters.
(2) Type ATI—40 pole—250 HP—0.8 PF—180 RPM—2200 volts, driving Tube Mills.
All these motors are equipped with automatic control and are used in Cement Plant.

more than 50% of full load torque is necessary for starting.

This motor has been applied in many industries. A large number are operating in cement mills driving crushing, grinding and pulverizing machinery and tube mills, where heavy starting torque is required. The motor may also be applied to centrifugal and other pumps where the by-pass connections are omitted, air compressors where unloading valves are not used, vacuum pumps, mine fans and other large blowers, rock crushing plants and ore dressing mills, paper mill pulp beaters, flour mill line shafts, rubber mill line shafts, some rolling mill drives and to machines having large flywheel effect and machines that are difficult to start when starting loaded with material.

The rolling mill drives referred to are used for rolling brass. For this service two super-synchronous motor drives are used. The motors are 500 horse



Type ATI—20 pole—500 HP—0.7 PF—360 RPM—440 volt super-synchronous motor, driving a Brass Rolling Mill.

power, 0.7 p. f., 360 r.p.m., for use on a 3-phase, 60-cycle, 440-volt line. This application is particularly interesting because the field of the motor is automatically put on the motor at the proper time and is automatically taken off when stopping normally or when stopping due to the action of the overload or undervoltage devices. Interlocking is provided so that the proper sequence in starting is accomplished with a minimum of manual operations. Should the field switch be left closed when stopping, no field will be put on the motor when starting again until the operator again closes the switch, as the field contactor is picked up through an interlock on the field switch. The undervoltage relay gives undervoltage protection to both motor and exciter set and is provided with a time

delay feature so that instantaneous voltage drops will not trip off the motor. The exciter and motor are arranged to trip together. On these particular equipments, an arrangement is also made to plug the motor should it be desired to stop quickly.

Approximately 98 super-synchronous motors have so far been built, aggregating approximately 39,000 horse power.

The general advantages of this type of drive may be summarized as follows:

1. The starting torque is the full pull-out torque.
2. The motor may be started with a low value of line current and will give a torque value in proportion to the line current when starting the load.
3. The motor may be designed with best operating characteristics as it is not necessary to sacrifice any of these characteristics to obtain high starting torque.
4. The use and maintenance of clutches and extra bearings is eliminated and the load may be accelerated more gradually.
5. The constant losses incident to the use of magnetic clutches are eliminated.
6. Space is conserved by this type of drive.
7. Ease of control, which permits starting high torque loads with a minimum of mechanical and electrical strain.
8. The brake and armature are stationary during normal operation, and the rotating parts are simple, as on the usual type of synchronous motor.

DISCUSSION: PRESENT DAY WIRE ROPE PROBLEMS.

(Continued from Page 318)

F. W. Cramer:* We tried several years ago, a rope with wire center on cranes and got an effect Mr. Howe did not mention; the outside seemed to stretch, while the core stayed the same length, giving a sort of a bumpy effect. The only way to get rid of that was to cut out the core, and we have discarded all ropes with wire centers on cranes. The hemp center seems to act like lubrication on ropes. The grease and oil is absorbed and then works out on the strands. That is a condition you do not get when using steel rope with wire centers, and the life of the rope with the hemp center was a great deal longer than the rope with the wire centers.

A. C. Cummins†: I think we should congratulate ourselves on having presented such a complete treatise on the design and use of wire ropes as we have just listened to by Mr. Howe. I jotted down a number of points, but a couple of minutes after I had them written down he would answer them, so that a great deal of my "thunder" has been disposed of.

One point we run into here in the steel mills that Mr. Howe did not touch upon, and that is the use of wire rope for slings. We had one very near serious accident at our plant when using wire rope for slings, and I think it might be very interesting to hear from Mr. Howe as to what safety factor should be used in building a sling and as to whether it should be more or less flexible than hoisting rope under similar loading. I would imagine the more flexible the rope the better the load would be distributed when used as a sling, and we should get a rope with a greater number of wires in them.

J. F. Howe: Any sling needs to be flexible, but the trouble is we have to put them around objects that are sharp cornered, and oftentimes it isn't protected where it goes around and the more flexible rope is cut by the sharp corners. Different methods are used for getting away from this trouble. We try to eliminate the cutting action, by taking pieces of wood and inserting them between the sling and the object being lifted so as to take the rope away from the hard cutting edge of the wheel or whatever we may be lifting; castings with rough edges or almost anything around a steel mill, and we need to protect against those things and to protect very carefully. There is one type of rope known as the steel clad, which gives some protection for that purpose. There have been one or two devices patented for taking care of this automatically. The one handling the sling needs to be well informed and posted not to let the sling get damaged by the rope rubbing against sharp corners. I think if that is taken care of, it is solved pretty nearly as far as it is humanly possible to solve it.

A. C. Cummins: In respect to ropes on ladle cranes. I think Mr. Howe has told us in a great many instances the reduction in strength is only in the neighborhood of one per cent if strands are broken only at intervals of three feet. We have always thought, in the practice in our own plant, that even if the rope appeared to be in perfect condition on the outside and there were no visible signs of broken strands, that after a certain period of service the rope had deteriorated more or less and, therefore, should be changed on general principles. I do not know whether this practice is followed by other steel mill maintenance departments, but I think we ought to hear some opinion expressed on that subject. Maybe some plants are really too conservative; maybe some of us are wasting money. I think there are gentlemen here who could give us practical data on that subject.

I took it for granted in Mr. Howe's talk in referring to his safety factor, it is safety factor with reference to ultimate strength. Most wire rope catalogs publish what they call a safe working load and also ultimate strength. A safe working load does not usually bear the relation to the ultimate load that factors of safety of 8, 9 and 10, or even 6, would indicate should be the safe working load for hoisting service.

In our crane service some mills make it a practice to make the hoisting blocks oil tight, so they can be filled with oil and the rope run almost continually in an oil bath. Others apply grease as the ropes go over the drums at frequent intervals. I would like to find out, if possible, if increased greasing, due to running rope in a bath of oil, warrants the trouble and extra expense and amount of oil that is wasted? It may be that is a needless expense and could be

---

*Asst. Elec. Engr., Bethlehem Steel Co., Cambria Plant, Johnstown, Pa.

†Supt. Elec. Dept., Carnegie Steel Co., Duquesne, Pa.

done away with, although I do not know but what it is the easiest way to grease hoisting ropes anyhow.

F. W. Cramer: Mr. D. M. Petty had a rope on a ladle crane that they were sort of testing out. I believe they left it on two years. They got a little suspicious and thought they had better take it off anyway, and naturally tested it, and only about 50 per cent of the strength was left in the rope, although as far as they could see there were not many broken strands in the rope. I know it is the practice at that plant not to leave ropes on ladle cranes longer than one year, and at our Johnstown plant we follow out the same practice; to remove the rope from ladle crane after one year's service whether broken or not.

R. F. Chaffin*: I think the author should be congratulated on the very complete paper given on the wire rope question, as it contains information valuable to the users of wire rope in general and steel works in particular. I believe there really is something to the so-called "quality" wire ropes. At Midland we have tried out quite a few of the various manufacturers "Pet Brands" and there is no doubt in my mind whatsoever that some ropes are considerably better than others.

It is our practice to keep tonnage records on rope life. I recall to mind the records of rope life on the Meade-Morrison Coal Hoist, where we were getting an average life of 60 to 80 thousand tons of coal handled per set of ropes, and by using a quality rope of "special seal-lay" construction manufactured by the Roebling people, and anchored in zinc, the tonnage per set of ropes has been raised to 141,000 tons.

It is our practice to purchase all our wire rope cut to length for cranes, hoisting equipment, conveyors, skip hoist, etc. I believe the only way to beat the wire rope problem is to avoid as much as possible the use of ropes. I have in mind a rope driven set of cone rollers which are in use as a run out from our merchant mill to a Morgan Hot Bed, where worn ropes were the source of considerable grief and expense. On a recent similar installation individual motor driven cone rollers were used, which have worked out very nicely

R. J. Harry†: The steel rope manufacturers state that best results are obtained when a rope winds in one direction only. If better life of rope is obtained thereby, why don't the crane manufacturers adopt this as standard practice?

Trolley approaches make it sometimes necessary for the ropes to have a 90° or 180° reverse bend on account of the design of hook block. I would like to know what difference in the life of rope is obtained by using reeving where the rope wraps in one direction only, and where a 90° or 180° reverse bend is used?

In buying short length of rope we find that the ends are wrapped with a short piece of wire to prevent the ends from unraveling. The wrapping wire sometimes comes off in handling. We weld the ends of practically all of our short lengths of wire rope, and I think it would be a good thing for the rope manufacturers to adopt the welding of the ends as standard practice.

A. G. McGarvey*: I was very much interested in Mr. Howe's paper. He brought out quite a few important points. One thing that has been discussed this evening is the proper method of fastening cable ends. The socket method stands up very well on elevators. We use sockets at both ends of the cable and they have stood up, some of them, as long as four years. Anyone having elevators will find that the socket method of fastening the ends of the cable is very satisfactory.

In order to determine when a cable ought to be removed, we inspect each and every part of cable every week. When six strands on any one cable have broken, it is taken off. All of our passenger elevators have six hoisting cables. When any one of these six cables has six strands broken, they are all replaced. In this way, cables are kept from breaking and accidents are avoided.

R. M. Hussey†: One thing that I did not hear Mr. Howe mention in detail at all, that is the matter of dead-ending cable. I would like to know what would be recommended as good practice in the matter of dead-ending, how they should be put on and the proper way to put them on. I think quite a lot could be said for the proper method and manner of dead-ending cable. It may not be much of a concern for the cable designer and manufacturer, but it certainly is for the man who has to use it and put it on the crane.

J. F. Howe: The question of dead-ending ropes is something that hasn't had any too much attention paid to it. On a crane you ought to have a certain number of laps. That is also true on mine hoist. On mine hoist they should have not less than three full laps around the drum, so there is friction enough so that the clamp on the end of the rope will not pull off. That is the whole thing in a nutshell. We do not have 100 per cent fastening strength with clamp, probably not over 50 per cent, but if you have several turns on the drum there is friction enough to have 100 per cent. When crane rope is too short, say it has been run out, so there is less than a lap on the drum, that is a dangerous condition. It is perfectly possible to take a rope and put it through a cast zinc cone and have it perfectly safe in that way. But with ordinary clamp, I do not think you get over 50 per cent of the strength of the rope in the clamp. That is a point you need to watch very closely. If you put it through the drum and fasten there is more or less of a cutting action. Sometimes you get an action caused by a rope working back and forth where it goes through the drum. You do on mine ropes if it is allowed to pay out too far. You get a worn spot there. I think there is a chance there for improvement in designing better fastening for attachment to the drum. Some have designed an offset socket that can be bolted to the drum. Others use "U" bolt clamps or plate clamps with bolts and nuts. All kinds of designs are used and a lot of them are not very good.

R. M. Hussey: I had in mind the dead-end of cable; not so much the end on the drum where

*Supt., Electrical, Steam and Hydraulic Departments, Crucible Steel Co., Midland, Pa.

†Elec. Engr., Carnegie Steel Co., Homestead, Pa.

*Chief Engineer, Wm. Penn Hotel, Pittsburgh, Pa.

†Elec. Supt., J. & L. Steel Co., Woodlawn, Pa.

you have a chance to put 4 or 5 wraps, but the other end of the cable. I would like to know how many clamps to use, the manner of putting them on and the proper kind of clamps to use?

J. F. Howe: You would want a whole line of clamps and it is better to use clips. It may look like it is holding firmly, but it isn't. I know a case where a rope broke when 6 clamps were used and with just the weight of the workmen, it went down. The trouble is that when you put these clamps on the rope it isn't under load and you squeeze the bolts up and think you squeeze them up tight enough. Tension decreases the diameter of the rope and it slacks off the tension on the clamps and bolts. With clips you can squeeze them down enough, but you must not squeeze too much. Even clips of 5/8", a rope with three clips on there and you can't get over 85 per cent. You will have to tighten them during the test in the testing machine. It is much better to splice a thimble or eye into the rope. It is also much safer and you get a job that will be better all around. You have to go over and tighten them up with the load on. A well-made splice would be 90 per cent efficient using 4 or 5 tucks on each strand.

W. C. McKibben*: We do not have any set time to change our cables, but they are inspected each week and when they show signs of too much wear, we replace them, keeping a complete record showing size, length, from whom purchased, date installed, date removed and on what crane the cable was used.

No grease or oil is applied to the cables on account of the objections to it dropping on the men working under cranes and on the finished product in the machine and roll shops.

Six part 7/8" cable is used on the main hoists of our 35-ton foundry cranes and we average about two years' service from these cables. Longer service is received from the cables on our machine and roll shop cranes.

I have had some experience with cables on ore bridges, skip hoists, etc., but since getting away from them, my cable problems have been few.

Robert R. Ellsworth†: What would you advise as a lubricant for rope? In regard to clamping rope on a drum, we take a drill on the end of our drum, cut a large hole in the center, bring the rope through and clip it together. We think we have a much better arrangement than clipping dead-ended right on the drum.

J. F. Howe: There are several different ways of lubricating. This method that has already been explained by Mr. Cummins of making the block tight and putting oil down inside appeals to me. You can get oil into the strands fairly easy, but if you attempt to put grease on the outside, it isn't going to go right in. It may work in after a while, but oil will work in immediately and should pick up enough dust and dirt to bind itself in there. That method of lubricating with light oil has been used very successfully in a lot of places, for instance, on an elevator where you don't want to have much grease dripping off the rope. You put a can on and let it drip once in 3 or 4 seconds and it is all right, and then take the can off when you have the rope lubricated with enough lubricant and not too much. A rope needs a certain amount of lubrication and if you can get that amount on without getting too much that is the scheme. There are different ways of doing it, but this appears to me one of the best methods that could be used. If you find you can make up a wiper and soak that pretty well, all right, but while you are doing that you have to leave the crane out of service. You can also use heavier grease to be applied once a month or something like that, but a lubricant applied constantly in a small amount is much better than occasional doping, because in between these you probably need it worse than any other time.

W. E. Houseman*: In referring to coal hoisting as a part of regular shaft operation and to the matter of dead-ending the rope, our standard practice is to zinc socket these ropes into drop forged sockets. This can best be done at the factory, but it is necessary to frequently carry out this process in the field. Our ropes vary up to 1 5/8" in diameter, and it requires three of our best men to socket a rope. We re-socket every three months, but frequently re-socket in less time, because of broken wires at the top of the socket, due to the whipping action of the rope. In most of the shaft mines in Illinois the zinc socket is not used, but instead an ordinary wire rope thimble is used, the rope bent around the thimble and seven to nine Crosby clips used to draw up the rope. The records would indicate that, except in very exceptional cases, they do not have trouble with strands breaking in the whipping action, from the fact that the rope is flexible throughout.

At the instance of one of our superintendents we had a section of 1½" rope made, reeving it around a thimble at each end and fastening it with seven Crosby clips at each end, tested it through the Pittsburgh Testing Laboratory, when the rope broke without the fastenings failing. We have been using this fastening for three years at the one operation, and have noted no breakage of wires at the clamps. Would like to have your opinion on this style of fastening for this particular type of service.

James F. Howe: Of course, the reason for recommending zinc socket is you have 100 per cent fastening. The 100 per cent fastening is always better than this from a safety factor, but what happens to that socket is this: Any adjustments where you go from the rigid action to the flexible, the vibration stops where the rigid action begins and the flexible action stops and when vibration comes to that point and stops it causes that breakage which has been referred to, and that is the reason why cables need to be resocketed at intervals. Thre are other reasons that are equally good why they should be socketed, but the mining law of the Transvaal in South Africa is very explicit and insist on renewal of socket fastening every three months. The U. S. Bureau of Mines Bulle-

*Supt. of Maintenance, Lewis Foundry & Machine Co., Coraopolis, Pa.

†Dist. Fore., Bethlehem Steel Co., Johnstown, Pa.

*Asst. Mech. Engr., H. C. Frick Coke Company, Scottdale, Pa.

tin No. 75 shows that the reliability of socketing depends on the speed of the rope and various other factors, figures renewals from 2 to 6 months or 8 months. In some cases, where the vibration set up is not so severe, you can run 6 to 8 months without breaking. In other cases they will show up in three. Another reason why the rope should be recapped is to change from the same spot on the drum. Where the rope stops on the drum you will find broken wires. If that spot is changed every so often you get away from that trouble and so, you have got two points to look at. Of course, clip fastening isn't entirely rigid. It allows vibration to crawl ahead and work around the tumbler somewhat and that is the only talking point for clip. Of course, there are enough talking points against it. Some people, when they see 6 or 8 clips on there think that is holding, but you never know. It depends on the man tightening them up and whether he has re-tightened them, and also when you tighten them very tight you always distort the rope. You have to do so to make it hold. But often, with "U" bolts, they are put on part on one way and part another, that is "U" bolts on what we term the short end of the rope. It is easier for a man to put them on reversed, because he thinks he gets the rope straighter and that condition will exist sometimes. If you put a curve on a rope it is always trying to straighten itself, so whatever is done you have got to watch your condition. I personally feel socketing is much better even if you have to re-cap, because there are ways of doing that which make it safer. Let the wires stick above the zinc ½" to ¾", and every time in the morning, when men go down in the shaft they can look up and see those wires sticking out. If they are seen it is safe; if they start to disappear, there is a sign it is drawing out of the socket. There is an absolute indication of safety. But you will get broken wires at other places than at the top of the socket, and I do not think it should be condemned because you get broken wires there. You get them at the drum and at the overhead shieve. So you have several places to watch. The one thing about the clip, a man can put them on a little easier. You don't have to have the same man to put on clips that you have to have to put on socket. When putting on the socket he has to know the difference between babbitt and zinc. If he ever uses babbitt, "God help you." If he uses zinc everything is perfectly safe.

Items of Interest

A 9,000-horsepower synchronous motor, to be installed by the McKinney Steel Company at its River Furnace plant, Cleveland, will have the highest continuous horsepower rating of any industrial motor in the world. This motor will be direct connected to a Morgan continuous billet mill, which will probably be in operation early in 1926.

The mill will have 10 stands of rolls, six of which will be 21-inch and the remainder 18-inch. The motor will be made by the General Electric Company and will be rated 9,000 horsepower, 107 r.p.m., 6600 volts, 3 phase, 25 cycles, to operate at unity power factor. The motor will have a shaft extension on both ends and will be coupled to a long lay shaft running the length of the mill with bevel gearing to each stand of rolls.

This will be the first large steel rolling mill in the world to be driven by a synchronous motor. Practically the only other instance of an application of this kind is in the case of some tube rolling and piercing mills in this country which are driven by synchronous motors of approximately 1,000 horsepower. The usual practice has been to drive such a mill by an induction motor. The McKinney Steel Company now has in use a Morgan mill of practically the same size, but of somewhat lower speed, driven by a General Electric, 5750-horsepower, 40°, 94 r.p.m., induction motor, which has been in service for about nine years.

A wire straightening machine that will prove to be an economy in almost every factory is the latest product placed on the market by the Kane and Roach Company of Syracuse, N. Y. This machine will salvage 95 per cent of the wire put into it no matter how badly twisted.

The machine is simply constructed, consisting of eight rolls, the first two of which act as pinching rolls, being equipped with spring adjustment to prevent shaft strain. The remaining six rolls are staggered, all but one upper roll, being driven by gears. These rolls are all made of tool steel, heat treated and hardened. The shafts are of high carbon steel, accurately machined and polished. A feed guide made of high carbon steel directs the wire into the rolls. Passes in the rolls are so cut that once the machine is adjusted, it is unnecessary to readjust the rolls for each size of wire other than to raise or lower the last roll to correct the tendency of the wire to go up or down as it is delivered from the machine. All rolls and gears are covered by guards which protect the operator. The machine has a capacity for 1/16" to ⅜" wire core, and from 150 to 200 feet of wire a minute.

The machine is connected through reducing gears to a Westinghouse 2 hp. motor, operating at 1140 r.p.m. The motor is suspended under the main frame of the unit. The entire unit is neat appearing and sturdy of construction, and with a very little practice an inexperienced man can operate it without any difficulty.

One of the most noteworthy developments in the design and construction of electrical fuses recently has been made by the Chicago Fuse Mfg. Co., of Chicago, pioneer manufacturer of electrical protecting materials and conduit fittings. It consists of modifications in the company's line of "Union" renewable fuses of the knife-blade type, which make these fuses exceptionally simple in design and construction.

To fuse users the significance of this development is that features of extreme durability and easy renewal have been added to the consistent and reliable performance which has characterized "Union" renewable fuses, and these features will serve to minimize the cost of fuse maintenance wherever they are used. Durability is gained by the rugged construction made possible by simplified design, and an unlimited number of renewals is afforded, thus giving maximum length of service. Renewal also is made easy, reducing the time and labor required to a minimum.

When the fuse is taken apart for renewal of the fusible element, there are only three loose parts—the fibre case, to which the threaded brass ends are securely attached; the knife-blades, which are connected by a rigid fibre bar and to which the fusible element is bolted; and one of the loose screw caps which hold the knife-blade member in position.

All that is necessary to disassemble the fuse is to unscrew the two caps, and then slip out the entire knife-blade member after one end of it has been shifted slightly to get it out of its locked position. One of the caps can be removed, but the other is held on the knife blade by two nibs. Assembly is accomplished just as readily, and the ease and quickness with which the entire operation can be done, together with the small number of loose parts, reduces time and trouble in making renewals to a minimum.

Extra heavy grey horn fibre is used in the construction of the case so that it will withstand the pressure developed by the blowing of the fusible element. The brass ends are securely attached to th fibre, and venting, which is an important feature of fuse operation, is accomplished by means of a number of grooves cut longitudinally in the fibre, where attachment is made to the brass ends. After the ends are put on, these grooves become ducts, which are large enough and of sufficient number to permit the escape of the gases caused by the volatilization of the fusible element and to relieve the case of the pressure generated; yet they are small enough so that the flame is effectually quenched before it reaches the outside. Also, these vents prevent molten metal from getting into the threads of the caps and causing them to stick and make removal difficult.

The knife-blade member, to which the fusible element is attached, consists essentially of two sections of flat copper, which are connected by a rigid fibre bar. These connections are made by means of rivets and screws, and the assembly is so rigid and substantial that the copper blades are positively held in position and perfect alignment, assuring permanent contact with the clips. The connecting bar, which is attached by means of screws, may be readily replaced in the event of damage or breakage.

The fusible element makes direct contact with both knife-blades and is held down at each end by a stud and washer. When making renewal these studs need to be loosened only slightly, and the fusible element, which is notched at both ends, can be slipped in and the studs tightened; there are no through bolts, with heads that have to be held or nuts that can be lost or misplaced. The design of the fusible element is an exclusive feature of "Union" renewable fuses, which blow without violence or flash, fusion occurring midway between contacts so that the metal parts are always clean.

These new fuses will be fully approved by the Underwriters and are made in all standard ratings—from 65 to 600 amperes, 250 or 600 volts.

The first two of a new line of automatic starters for squirrel-cage and single-phase motors have been developed and placed on the market by The Cutler-Hammer Mfg. Co., Milwaukee.

Both of the new "X" Starters have a three-pole switching mechanism with butt contacts of an improved design that insures long service and permits easy renewal of the contacts. The switching mechanism, terminals and overload devices are mounted on a slate panel which is enclosed in a steel cabinet provided with knockouts for conduit wiring, and the entire construction is exceptionally compact, the cabinets being only 13½ inches high by 9 inches wide by 6 inches deep. The cabinets are arranged for convenient mounting on wall, post or machine.

One type of these new starters, the Bulletin 9585 type, is equipped with thermal overload cutouts to provide protection against overload, but which carry the starting current for a sufficient period to permit starting of the motor and to take care of temporary overloads.

This starter is for use with single phase and standard polyphase squirrel-cage motors of maximum rating of 7½ hp., and 10 hp. for internal starter squirrel-cage motors, 440-550 volts.

The Bulletin 9586 starter is equipped with a thermal overload relay of a new design that is claimed to be the most accurate and sensitive ever developed for an automatic starter of the across-the-line type. It does not trip on momentary overloads, but quickly responds to maintained overloads or short-circuits, giving complete protection to the motor. The relay is reset after tripping by pressing a reset button, which projects through the cover or automatic resetting can be obtained as an optional feature. This starter has a maximum rating of 15 hp., 440-550 volts for single-phase and standard squirrel-cage motors; and 30 hp. for squirrel-cage motors with internal starters.

Both the Bulletin 9585 and Bulletin 9586 starters can be operated by means of push-button master stations, or they can be used in connection with float switches, pressure-actuated switches, and similar single-pole switching devices. Starters with three-wire push-button control provide low-voltage protection because the operating coil is de-energized when the line voltage decreases materially, and it is necessary to operate the push button in order to start the motor again. Starters with two-wire float switch control provide low-voltage release because the operating coil is sufficiently de-energized, when the line voltage decreases materially to cause the contactors to disconnect the motor, and when the voltage is restored the coil is energized and the motor connected to the line if the float or other control switch has remained closed or is closed again.

T. V. Buckwalter, who has been Chief Engineer for The Timken Roller Bearing Company, was made Vice President in charge of Engineering, at the July meeting of the directors of the company.

The year 1924 witnessed further development in standardizing activities in many branches of our national industries, as is evidenced by the lengthening list of standardization projects before the American Engineering Standards Committee.

The following groups of industries are represented at present with a total of 159 projects submitted, including 68 approved standards.

Group	Projects Total	Approved
Civil Engineering and Building Trades	32	16
Mechanical	26	10
Electrical	17	5
Automotive	4	1
Transportation	9	6
Shipbuilding	1	—
Ferrous Metallurgy	9	7
Non-Ferrous Metallurgy	14	6
Chemical	12	9
Textile	2	1
Mining	16	1
Wood	5	2
Pulp and Paper	1	—
Miscellaneous	11	4

The 15 new projects submitted for approval during the year are distributed in the following way: two are in the group of civil engineering and building trades, one each in the mechanical and electrical groups, and 11 in the mining group.

Civil Engineering and Building Trades

An important new line of work is the unification of specifications for cast iron pipe, an undertaking which was launched at a conference at which 29 interested organizations were represented. The work is being co-ordinated with that of the sectional committee on pipe flanges and fittings, which is already well advanced.

Four standards dealing with specifications and methods of test for road materials were approved during the year. Progress was made on a systematic organization to deal comprehensively with the entire subject of methods of testing road material, which would probably ultimately involve 50 or more methods of test.

A code for the lighting of school buildings was approved. Two more specifications for the design and construction of steel highway bridge superstructures were submitted, making a total of four steel bridge specifications under consideration by a special committee.

Mechanical Engineering

The most important piece of work in the mechanical field during 1924 was the completion of the standard for screw threads, a subject which vitally interests practically every industry. This was worked out in co-operation with the National Screw Thread Commission. Another standard closely allied to this was the approval of the standard screw thread for fire hose couplings, which has been in the course of development for many years by important organizations in this country. This is especially important, as it marks for the first time a national agreement on tolerances or limits of accuracy necessary to secure interchangeability in manufacture. The previous lack of uniformity has been shown in a startling way by the exhibit in a single collection of 600 sizes and variations of fire hose couplings. Heretofore manufacturers have worked almost entirely from samples of couplings submitted by the purchasing authority, instead of by the use of accurately made gages. In connection with the standard, the sponsors issued two publications, one for the use of fire chiefs and superintendents of waterworks, explaining in simple terms the methods of securing complete interchangeability through the use of inspection gages, and the other for the guidance of manufacturers.

A standard dealing with diameters and lengths of cold finished shafting was approved, and in connection with this, work on the subject of standard keys and keyways is well advanced.

Important progress is being made by the sectional committee on pipe flanges and fittings, on which 32 organizations are represented. This includes a revision of the 1914 A S M E standards. The work on the standardization of steel flanges and flanged fittings for high pressures and 750° superheat involved the laying down of complete new designs and represents the somewhat unusual case of necessary standardization guiding industrial development.

Great progress has been made in another far-reaching subject—tolerances and allowances for machined fits in interchangeable manufacture. The first part of the work on this subject, which is under the sponsorship of the American Society of Mechanical Engineers, is nearly ready and will be issued soon.

Work on dimensions and tolerances for bolts, and nuts is well advanced. A tentative proposal covering the range of from ¼ to 3 inches in diameter, and greatly reducing the number of wrench openings, has been worked out. Certain important details have yet to be considered, but the complete standardization of all the bolts and nuts commonly used in the United States is already in view. At an informal conference of representatives of the American, Czecho-Slovakia and German committees, held recently in New York, it was recommended that there be held a general international conference looking toward agreement so that there may be international interchangeability in regard to wrenches, nuts and bolt heads.

Electrical Engineering

Work on the revision of two important electrical codes is well under way, the "National Electrical Code," which covers fire hazards, and the "National Electrical Safety Code," which covers casualty hazards.

At a large representative conference, it was unanimously agreed to undertake the unification of overhead line materials, including certain classes of insulators. This work, together with that now under way on the unification of specifications for poles, and specifications for bare and insulated copper conductors, some of which have already been approved, covers in a pretty thorough way most of the important features of overhead lines for power and communication service.

Ferrous and Non-Ferrous Metallurgy

Two specifications for steel forgings for general purposes, and specifications for high sheet brass, ingot metal, and solder, were approved during 1924.

As the result of a large conference, at which 39 organizations were represented, work has been or-

ganized on the unification of specifications for zinc coating of iron and steel, which it is hoped will remove the very unfortunate variations now existing in the quality of such products as fence wire, water pipe, galvanized sheets, and numerous other zinced articles.

Mining

A particularly important feature has been the development of the work on mining. Until the very recent past, little standardization had been carried out in the mining industry. Work on 11 mining projects has been started under A E S C procedure during the last year. These include codes for rock dusting, mine illumination, ventilation, use of explosives in coal mines, and underground transportation. The Mining Standardization Correlating Committee found it desirable to have these simple codes, dealing primarily with safety in the mining industry, prepared in order to serve as a guide in pending legislation.

Safety

Technical standardization is coming to play a very important role in the safety movement. Substantial progress has been made on a program of some 40 codes, most of which are applicable to factories. Thirteen of these have been completed, and work on half of the remainder is well advanced. Codes for woodworking machinery, logging and sawmill machinery, laundries, and school lighting, and a revision of the code for punch presses, were completed and approved during the year. Taken as an example, the woodworking safety code is primarily intended to cover the hazards at the "point of operation" in woodworking machinery from the crude lumber to the finished product. It deals with plant layout, machines, equipment and operating rules.

Substantial progress has been made on the code for automobile brakes and brake testing; also on the code for traffic signals. These two projects, together with the code on automobile headlighting, played an important part in the large conference on highway safety, called by the Secretary of Commerce in December, 1924.

Preferred Numbers

A new project in the miscellaneous group is that of preferred numbers, which has been much discussed in connection with the European standardization work. American engineers are beginning to inquire into the great possibilities of economies which it may be possible to bring about through the adoption of a systematic scientific basis for the selection of sizes of industrial products. In the European system each size represents a term of a geometrical progression, as for example, the series, 10, 16, 25, 40, 64, 100, 160, 250, etc, in which each step is about 60 per cent larger than the preceding one. It seems certain that the adoption of preferred numbers by industries, especially in mass production, will mean decreased cost through a reduction in apparatus, tools, fittings and supplies necessary in the production, distribution, and use of manufactured products.

Government Co-operation

The Federal Specifications Board has now adopted nearly 300 specifications. These are used as a basis of purchase throughout the Federal government. The A E S C has continued its co-operation in this work, and during the year has circulated more than 100 of these specifications for criticism, in order to determine their acceptability in industry before official adoption by the government.

The third year of the work of Mr. Hoover's Division of Simplified Practice has shown extensive development. In all, 26 simplifications have already been carried through, 10 others are in the final stages, and 45 additional surveys are now under way. Two hundred industrial groups are co-operating in the various projects. The U. S. Chamber of Commerce and the A E S C are co-operating closely in this work.

The work on the "Directory of Specifications," being carried out by the Bureaus of Standards and of Foreign and Domestic Commerce, is nearly ready for publication. This will consist of a classified list of all of the more important purchase specifications in existence in this country. It has been carried out primarily for the use of public purchasing bodies, to which, as well as to industries in general, it should be of great service.

The co-operation of the Federal government with industry through the machinery of the A E S C steadily increases; in fact, one or more arms of the government are co-operating in nearly every one of the A E S C projects. The Bureau of Standards and the Federal Specifications Board jointly maintain a liaison officer in the A E S C.

Foreign Co-operation

Standardization activities in foreign industrial countries continue to increase. Among the newer national organizations those in Czecho-Slovakia and Japan are showing great activity. The former has approved 5 standards, and has no less than 176 other projects under way, and the latter is working on 53 projects, and has 2 approved standards. In all, there are now 19 national standardizing bodies, with all of which the A E S C is in active touch.

Heretofore, there has been no very active development of standardization activities in Latin America, and hence the Pan-American Conference on Standardiaztion, which opened in Lima, Peru, on December 23, was a notable event. Thirteen American states were officially represented, the retiring chairman of the A E S C, Mr. A. W. Whitney, acting as chairman of the official American delegation. The general idea of the undertaking originated with the Latin American countries. Through such conferences the way may be paved to extremely valuable developments in future.

Interest on Part of Industry

By action of a conference of first-line executives a strong advisory committee of their number has been organized. The committee will assist in keeping executives in touch with the national movement in its development and in extending its influence and support, both intensively and extensively, among industrial groups.

Hitherto the movement has been largely centered in and carried on by the technical man. The appointment of the committee marks definite recognition of the fact that standardization has now become a managerial problem of the first rank in industrial production, distribution and utilization, and as such deserves the fullest industrial support.